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NEWBIGGING'S HANDBOOK FOR GAS ENGINEERS AND MANAGERS

THIRD EDITION

THE
GAS MANAGER'S
HANDBOOK.

THIRD EDITION,

ILLUSTRATED.

THE
GAS MANAGER'S HANDBOOK;

CONSISTING OF

Tables, Rules, and Useful Information

FOR

GAS ENGINEERS, MANAGERS,

AND OTHERS ENGAGED IN THE

MANUFACTURE AND DISTRIBUTION

OF

COAL GAS.

BY

THOMAS NEWBIGGING,

MEMBER OF THE INSTITUTION OF CIVIL ENGINEERS.

THIRD EDITION, ILLUSTRATED.

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THIS

THIRD EDITION OF

THE GAS MANAGER'S HANDBOOK

IS

Respectfully Dedicated

TO THE MEMBERS OF

THE GAS INSTITUTE,

BY THEIR OBLIGED AND FAITHFUL SERVANT,

THOMAS NEWBIGGING.

ever, published in a separate *brochure* for the use of those who may desire to have them.

The pages of the work have been enriched by many additional Tables, to the authors of which I tender my warmest thanks. I take the opportunity, also, of thanking my publisher, Mr. Walter King, for his efforts to give the "HANDBOOK" its present acceptable form.

T. N.

5, NORFOLK STREET, MANCHESTER,
March, 1883.

PREFACE

TO

THE FIRST EDITION.

THE present work has been compiled to supply a want which has long been felt by Gas Managers. Though there are several well-known excellent, and comprehensive treatises on Gas Lighting, and on the Chemistry of Gas Manufacture, and many valuable manuals bearing on particular branches of the subject, no Handbook has yet appeared embodying in a convenient form the various Rules, Tables, and other data so frequently required for reference in successfully conducting the operations of gas-works.

It is not possible, nor is it desirable, that a work of this kind should consist of entirely original matter. To be really useful it must bring together, in systematic order, whatever of value it can glean, not only from the few standard treatises on the subject, but also from the periodical literature of Gas Lighting, and the numerous pamphlets and other publications constituting the library of the Gas Engineer At the same time, a cursory glance at the contents of the volume will show that there is much original matter of an acceptable kind distributed throughout its pages.

My very grateful acknowledgments are due to Mr. T. G. BARLOW, C.E., for his kindness in so readily and courteously permitting me to extract from the earlier volumes of the *Journal of Gas Lighting* his comprehensive and valuable Tables on the Flow of Gas through Mains, and those of Mr. LEWIS THOMPSON, giving the results of the analyses of different varieties of Coal and Cannel. I am also indebted to Mr. HARTLEY, of Millbank Street, Westminster, for leave to reproduce the Specific Gravity Tables of Mr. ALEXANDER WRIGHT, from his useful little work on the "Analysis of Coal Gas;" and to Mr. WILLIAM SUGG, of Vincent Works, Westminster, for allowing me to print his Photometer Tables from the late Mr. BANNISTER's volume on "Gas Manipulation." On the Chemistry of Gas Lighting there are no higher authorities than Dr. LETHEBY and Professor FRANKLAND, and I have availed myself of the result of their labours in several instances. Other sources of information are acknowledged in the body of the work.

T. N.

March, 1870.

PREFACE

TO

THE SECOND EDITION.

The favourable reception which was accorded to the first edition of the "Gas Manager's Handbook" sufficiently proves that it supplied a generally acknowledged want.

In the present edition, the work has undergone careful revision, much new matter has been added, its form has been altered to suit alike the pocket and the desk, and every effort has been made to increase its usefulness, and render it worthy of the position it aspires to fill.

I am indebted to the Press, and to many friends, for the interest they have taken in the success of the work, and for valuable suggestions, which I have adopted as far as practicable.

T. N.

Pernambuco,
November, 1878.

PRINCIPAL CONTENTS.

[*For Alphabetical Index, see end.*]

PAGE
Coal and Cannel 1–49
Retort House, Retort Benches, Retorts and Mountings . . . 49–76
Condensation and Condensers 76–87
Exhausters 88–90
Steam Boiler and Engine 90–92
Washers 92–93
Scrubbers 93–97
Bye-Pass Mains and Valves 97
The Tar Well 98–99
Purification and Purifiers 99–110
Tests for the Detection of Impurities 110–120
Station Meter House and Meter 120–122
Pressure Gauges 123
Pressure and Exhaust Registers. 123–124
Gasholder Tanks 125–144
Gasholders 144–162
Station Governor and District Governors 162–165
Main Pipes 165–186
Discharge of Gas, in cubic feet per hour, through Pipes of
various Diameters and Lengths, at different Pressures . . 187–198
Service Pipes and Fittings 199–205
Public Lighting 206–209
Consumers' Gas Meters 210–228

PAGE
Internal Fittings 227–237
Public Illuminations 238–244
Illuminating Power 244–261
Specific Gravity of Gas 261–266
The Use of Gas for Cooking, Heating, and Motive Power. . . . 266–269
The Residual Products 270–279
Coal Products 280–293
Chemical and other Memoranda 294–299
Sundry Useful Information Relating to Gas Works, Gas Apparatus, Gas Manufacture and Supply 300–308
Miscellaneous 308–326
Office Memoranda 327–333
Epitome of Mensuration 334–335
Arithmetical and Algebraical Signs 335–336
Approximate Multipliers for Facilitating Calculations . . . 336–337
Table of Squares, Cubes, Square Roots, Cube Roots, and Reciprocals of Numbers 338–364
Table of the Fourth and Fifth Powers of Numbers 364–365
Table of Diameters, Circumferences, and Areas of Circles, and Sides of Equal Squares 366–369
Weights and Measures 370–373
French Weights and Measures, Decimal System 374–375
Alphabetical Index 376–419

ILLUSTRATIONS.

FIG.		PAGE
1	Specific Gravity Balance	44
2	Bench of Retorts	50
3–5	Sections and elevations of Buckstaves	51
6	Coke-slaking Apparatus	51
7	Retorts—Round, D-shaped, and Oval	53
8	Brick Retort and Tiles, section	54
9	Furnace Ash-pan	58
10	Fraser's Ribbed Iron Retort, section	58
11–13	Retort Mouthpiece Lid and Fittings	65
14	Lug for Retort Mouthpiece	65
15	Price's Coke and Coal Barrow	67
16	Charging Scoop	68
17	Discharging Rake	68
18	Auger	68
19	Ash-pan Rake	68
20	Ditto Shovel	68
21	Fire-tongs	68
22	Pricker	68
23	Bridge and Dip Pipes	69
24–26	Hydraulic Main—various sections	70
27	The "Livesey" Hydraulic, section	70
28	Atmospherical Vertical Condenser	79
29	Kirkham and Wright's Annular Condenser	80
30	Horizontal Condenser	81
31	Tubular or Battery Condenser	82
32	Beale's Exhauster	88
33	Jones's ditto	88
34	Laidlaw's ditto	88
35	Cleland and Körting's Steam-Jet Exhauster	88
36	Anderson's Exhauster	89
37	Exhauster Governor	90
38	The Tower Scrubber	93
39–40	Separator for Tar and Ammoniacal Liquor, section and plan	98
41	Purifiers and Centre and Four-way Valves	106
42	Tray or Grid for Purifiers	108
43–45	Drory's Main Thermometer	110
46	Referees' Sulphur Test	112
47	Harcourt's Colour Test	113

FIG. PAGE
48 Station Meter—Cylindrical . . . 121
49 Ditto Rectangular . . . 121
50–51 Pressure Gauges . . . 123
52 King's Pressure Gauge . . . 123
53 Differential Pressure Gauge . . . 123
54 Crosley's Pressure and Exhaust Register . . . 124
55 Wright's Pressure Register . . . 124
56 Gasholder Tank—Brick and Puddle . . . 125
57 Ditto Cast-iron . . . 125
58 Ditto Annular . . . 125
59 Natural Slope of Earths . . . 126
60 Gasholder—Single Lift . . . 145
61 Ditto Three Lift (telescopic) . . . 145
62 Braddock's Station Governor . . . 163
63 Peebles's District or Differential Governor . . . 164
64 Turned and Bored Joint, with recess . . . 168
65 Ditto ditto without recess . . . 168
66 Ditto . . . 170
67–68 Open Joints . . . 170
69 India-rubber Joint . . . 172
70 Ball and Socket Joint . . . 172
71 Expansion Joint . . . 172
72–73 Syphons or Drip Wells . . . 174
74 Bag for Plugging Mains . . . 175
75 Hulett's Service Cleanser . . . 200
76 Service Pipes and Fittings . . . 203
77 Sugg's Street Lamp and Burners . . . 206
78–79 Bray's ditto ditto . . . 206
80 Siemens' ditto ditto . . . 207
81 Apparatus for Testing Meters . . . 212
82 Cowan's Ventilating Globe Light . . . 229
83 Strode's Ventilating Sun Light . . . 229
84–99 Devices for Illuminations . . . 240, 241
100 Letheby-Bunsen Photometer . . . 244
101 Sugg's "London" Argand, No. 1 . . . 248
102 The Referees' Cubic Foot Measure . . . 252
103 Ditto Pressure Gauge . . . 254
104 Lowe's Jet Photometer . . . 258
105 Kirkham and Sugg's Retrograde Scale . . . 259
106 Sugg's Illuminating Power Meter . . . 260
107 Thorp and Tasker's Jet Photometer . . . 261
108 Letheby's Specific Gravity Apparatus . . . 262
109 Wright's Specific Gravity Balloon . . . 265
110 Coke-breaking Hammer . . . 270
111 Stephenson's Apparatus for Testing Spent Oxide . . . 277

NEWBIGGING'S HANDBOOK

FOR

GAS ENGINEERS AND MANAGERS.

THE CHIEF KINDS OF COAL.

Cannel or Parrot Coal.—The richest Gas-producing Coal, well known by its hard smooth texture. The best varieties are found in different parts of Scotland, and at Wigan and Newcastle. The two latter yield Coke of fair quality; that from the former is less valuable, and much of it useless as fuel.

Bituminous Coal.—Including caking (Newcastle and Wigan), splint (South Wales and Scotland), cherry (Scotland and Lancashire), and other Coals, containing bitumen, and consequently of more or less value in the manufacture of Illuminating Gas. Yields Coke of excellent quality.

Anthracite or Glance Coal.—Chiefly Welsh, containing a large proportion of fixed carbon, but little volatile matter, and almost smokeless in burning. Excellent for steam purposes, but quite useless for the production of Illuminating Gas.

Lignite or Brown Coal.—Found at Bovey Tracey, in Devonshire, in a small field near Lancaster, and near Lough Neagh, in Ireland. Of no great interest to the gas maker. Yields but little Gas, and that of a low illuminating power, and a very unpleasant odour. Gives off a large quantity of water charged with acetic acid. Coke valueless as fuel.

TABULAR VIEW OF THE TRIAS, PERMIAN, AND CARBONIFEROUS SERIES IN ENGLAND AND WALES.

(PROFESSOR HULL.)

New red sandstone or trias	Keuper,	Red marl.
		Lower Keuper sandstone.
	Bunter	Upper mottled sandstone.
		Conglomerate beds.
		Lower mottled sandstone.
Permian rocks		Upper red sandstone of St. Bees, &c.
		Upper and lower magnesian limestones and marls of the Northern counties.
		Lower red sandstone of Lancashire, Cumberland, and Yorkshire, &c. (on the same horizon with)
		Red sandstones, marls, conglomerates, and breccia, of the central counties and Salop.
Carboniferous rocks	Upper carboniferous	Upper coal-measures with limestone, and thin coal seams.
		Middle coal-measures with thick coal seams.
	Lower carboniferous	Lower coal-measures, or Gannister series, with thin coal seams and lower carboniferous fossils.
		Millstone grit, with thin coal seams.
		Upper limestone shale, or Yoredale rocks.
		Carboniferous limestone with shales, sandstones, and coal in the Northern counties and Scotland.
		Lower limestone shale.

Old red sandstone and Devonian rocks.

TABLES

SHOWING THE CHIEF INGREDIENTS OF WHICH COAL IS COMPOSED.

Percentage Composition.

NEWCASTLE COALS.

Name of Coal.	Specific Gravity.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.	Coke.
Willington	..	86·81	4·96	1·05	0·88	5·22	1·08	72·19
Tanfield	1·26	85·58	5·31	1·26	1·32	4·39	2·14	65·13
Bowden Close	..	84·92	4·53	0·96	0·65	6·66	2·28	69·69
Haswell Wallsend	1·28	83·47	6·68	1·42	0·06	8·17	0·20	62·70
Newcastle Hartley.	1·29	81·81	5·50	1·28	1·69	2·58	7·14	64·61
Hedley's Hartley	1·31	80·26	5·28	1·16	1·78	2·40	9·12	72·31
Bates's West Hartley. . . .	1·25	80·61	5·26	1·52	1·85	6·51	4·25	..
West Hartley Main	1·26	81·65	5·29	1·69	1·13	7·53	2·51	59·20
Original Hartley	1·25	81·18	5·56	0·72	1·44	8·03	3·07	58·22
Average of eighteen samples from different mines . . .	1·25	82·12	5·31	1·35	1·24	5·69	3·77	60·67

LANCASHIRE COALS.

Ince Hall Company's Arley .	1·27	82·61	5·86	1·76	0·80	7·44	1·53	64·00
Haydock, Rushey Park . .	1·32	77·65	5·53	0·50	1·73	10·91	3·68	59·40
Blackbrook, Little Delf . . .	1·26	82·70	5·55	1·48	1·07	4·89	4·31	58·48
Wigan four feet	1·20	78·86	5·29	0·86	1·19	9·57	4·23	60·00
„ Cannel	1·23	79·23	6·08	1·18	1·43	7·24	4·84	60·33
Caldwell and Thompson's Higher Delf	1·27	75·40	4·83	1·41	2·43	19·98	5·95	54·20
Average of twenty-eight samples from different mines . .	1·27	77·90	5·32	1·30	1·44	9·53	4·88	60·23

DERBYSHIRE COALS.

Earl Fitzwilliam's Elsecar . .	1·296	81·93	4·85	1·27	0·91	8·58	2·46	61·60
Holyland and Co.'s Elsecar . .	1·317	80·05	4·93	1·24	1·06	8·99	3·73	62·50
Butterley Company's Langley .	1·264	77·97	5·58	0·80	1·14	9·86	4·65	54·90
Staveley	1·270	79·85	4·84	1·23	0·72	10·96	2·40	57·86
Average of seven samples from different mines	1·292	79·68	4·94	1·41	1·01	10·28	2·65	59·32

GLOUCESTERSHIRE COALS.

Coleford High Delf (Forest of Dean) .	1·219	78·810	5·303	1·750	2·062	9·055	3·020	63·97
" "	1·313	76·502	5·380	1·090	1·669	8·659	6·700	62·60
" "	1·331	74·410	4·470	0·700	2·370	8·840	9·210	59·76
" "	1·354	74·464	5·292	0·511	2·667	6·831	10·235	60·36
Trenchard	1·354	80·709	5·425	0·735	1·271	7·060	4·800	63·38
New Bowson, Cinderford. . .	1·332	76·860	5·430	1·680	1·940	9·330	4·760	58·24
" " . . .	1·307	79·310	5·250	1·260	0·850	9·100	4·230	59·22
Parkfield	1·374	82·069	5·613	0·940	1·457	6·391	3·530	60·97
Hanham	1·277	75·340	4·630	0·630	2·440	5·480	11·480	58·86
Warmley	1·304	82·410	4·870	0·770	0·870	5·230	5·850	71·15

SOMERSETSHIRE AND OTHER COALS.

Name of Coal.	Specific Gravity.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.	Coke.
Ashton	1·302	84·066	6·468	1·020	1·053	3·230	4·168	79·60
"	1·303	84·912	4·976	0·840	1·586	4·166	3·520	79·29
"	1·290	82·470	5·008	1·190	1·039	6·842	3·451	79·87
Nailsea	1·320	82·270	5·640	0·910	2·370	5·130	3·680	66·29
Derbyshire Gas Coal	1·286	77·249	5·513	1·120	1·667	11·195	3·256	56·01
" "	1·120	74·720	4·970	0·910	0·720	7·310	11·370	64·95
" "	1·302	78·905	5·436	0·840	1·471	10·928	2·420	55·40
" Cannel	1·271	74·846	6·285	0·350	1·318	14·201	3·500	54·75
Bulwell Nottingham Gas Coal	1·291	77·184	5·517	0·770	1·251	12·518	2·760	60·04
" " Cannel	1·269	78·680	5·872	0·700	0·690	9·378	4·680	56·64

SCOTCH COALS.

Boghead	1·218	63·930	8·858	0·962	0·320	4·702	21·222	31·70
Wallsend Elgin	1·200	76·090	5·220	1·410	1·580	5·050	10·700	58·45
Grangemouth	1·290	79·850	5·280	1·350	1·420	8·580	3·520	56·60
Eglinton	1·250	80·080	6·500	1·550	1·380	8·050	2·440	54·94

WELSH COALS (Fiddes).

Aberaman, Merthyr	1·300	90·940	4·280	1·210	1·180	0·940	1·450	85·00
Aberdare Co., Merthyr	1·310	88·280	4·240	1·660	0·910	1·650	3·260	85·83
Anthracite (Jones and Co.)	1·375	91·440	3·460	0·210	0·790	2·580	1·520	92·90
Coleshill	1·290	73·840	5·140	1.470	2·340	8·290	8·920	56·00
Llantwit	1·273	77·410	5·553	0·560	2·365	12·062	2·050	64·70
"	1·252	77·310	5·642	0·420	2·037	10·366	4·225	58·82
Nantgarw Llantwit	1·326	79·130	5·610	0·700	3·450	7·330	3·780	61·67
Rhos Llantwit	1·282	76·995	5·455	0·700	1·643	12·875	2·332	63·30
" "	1·302	75·452	5·497	0·840	2·312	13·023	2·876	63·03
" "	1·302	73·410	5·507	0·350	2·414	14·276	4·043	65·32
Holly Bush	1·269	80·134	5·045	0·518	2·279	8·522	3·502	74·42
Tyr Filkens	1·368	82·117	5·054	0·595	2·537	5·794	3·903	64·86
Llanhilleth	1·274	87·640	6·085	1·120	1·636	2·209	1·310	70·39
Aber Rhondda	1·320	80·675	5·082	0·910	3·675	2·763	6·895	70·81
Pontypridd	1·311	79·820	5·470	0·700	3·950	3·750	6·310	65·80
Wallsend	1·317	78·270	5·380	0·770	1·860	8·900	4·820	66·00
Energlyn	1·312	83·120	5·840	0·980	1·870	5·890	2·300	71·30
Rock Vawr	1·290	77·980	4·390	0·570	0·960	8·550	7·550	62·50

ANALYSIS OF THE ASH OF A GOOD NEWCASTLE COAL.

(Taylor.)

	Per Cent.
Silica	59·56
Alumina	12·19
Peroxide of iron	15·96
Lime	9·99
Magnesia	1·13
Potash	1·17
	100·00

TABLE

SHOWING THE TOTAL AREA OF COAL MEASURES IN THE UNITED KINGDOM. (CLEGG.)

	Area of Coal Measures.		Entire Area of Country.		Proportion of Coal to the whole.
	Square Miles.	Acres.	Acres.	Square Miles.	
In England	6,039	3,864,960	31,770,615	49,643	1-8th.
In Scotland & Islands, exclusive of Lakes.	1,720	1,100,000	18,944,000	29,600	1-18th.
In North Wales. . .	210	134,400	4,752,000	7,425	1-6th.
In South Wales. . .	950	608,000			
In Ireland	2,940	1,881,600	20,399,608	31,874	1·11th.
In British Isles . . .	..	..	1,119,159	1,748	—
Total . . .	11,859	7,588,960	76,985,382	120,290	—

Exclusive of wood-coal and lignite formations, and some small undefined areas.

ANALYSES OF COALS.

The following tabulated results of the analyses of the different kinds of Cannel and Bituminous Coals, by Mr. Lewis Thompson, though published as early as the year 1851, still constitute the most comprehensive and useful series of experiments (if we except those of Mr. James Paterson) that have appeared in this department of the science of Gas Lighting; and their general correctness and consequent value have frequently been proved.

It is to be noted that *dry* samples of Coal were employed in each experiment. The importance of using dry material will be apparent when it is remembered that the presence of moisture in Coal (besides giving rise to other deleterious compounds) increases the quantity of sulphur in the gas produced, by reason of its decomposition in contact with protosulphuret of iron;* its constituent elements—oxygen and hydrogen—combining, the oxygen with the iron, forming oxide of iron; and the hydrogen with the sulphur, producing sulphuretted hydrogen; thus causing the whole of the sulphur contained in the Coal to pass off into the gas; whereas, in the case of the dry Coal, as a rule rather more than one-half of the sulphur present is left behind in the residuary coke.

---

* Sulphur exists in Cannel in a free state, and in Bituminous Coals chiefly in combination with iron, as pyrites or bisulphide of iron, Fe S_2, and this in the retort is converted into sulphide or protosulphuret of iron, Fe S.

ANALYSES OF COALS.* (THOMPSON.)

CANNEL COALS.

Name and General Character of Cannel.	Volatile Matter	Coke.	Ash per Cent.		Nature of Ash.	Sulphur in		
			In Coal.	In Coke.		Coal.	Coke.	Volatile Matter.
ARNISTON.—Resembling lignite, and containing crystals of carbonate of lime, with impressions of leaves and deposits of iron pyrites. Compact. Principal fracture, slaty; cross fracture, irregular. Streak, dull brownish black. Thrown on the fire, it decrepitates, but does not fly. Colour of ash, a dirty grey; with nitrate of cobalt, greenish black. Specific gravity of coal, 1·1967.	45·5	54·5	4·18	7·66	Silicate of lime, alumina, and oxide of iron.	1·70	·95	·75
BOGHEAD.—Brown, compact, and massive, containing a few impressions of sigillaria. Princip. fracture, slaty, conchoidal; cross fracture, irregular. Streak, yellow. Thrown on the fire, decrepitates slightly, does not fuse, but splits. Colour of ash, white; with nitrate of cobalt, blue. Specific gravity, 1·221.	68·4	31·6	22·8	72·15	Silicate of alumina.	·53	·08	·45
CAPELDRAE.—Massive, dull black, impressions of sigillaria, with deposits of carbonate of lime and pyrites. Principal fracture, conchoidal and slaty; cross fracture, distinctly conchoidal. Streak, yellowish brown. Thrown on the fire, decrepitates, splits, and flies, but does not fuse. Ash, white; with nitrate of cobalt, blue. Specific gravity, 1·2275.	54·5	45·5	10·5	23·07	Silicate of alumina.	·65	·20	·45

---

* *From the Journal of Gas Lighting*, Vol. II., pp. 208, 228, 248, 262.

Name and General Character of Cannel.	Volatile Matter.	Coke.	Ash per Cent.		Nature of Ash.	Sulphur in		
			In Coal.	In Coke.		Coal.	Coke.	Volatile Matter.
Kirkness.—Massive and foliated, free from foreign matters. Dull brown. Principal fracture, slaty; cross fracture, conchoidal. Streak brown. Scarcely decrepitates on the fire. Colour of ash, whitish grey; with nitrate of cobalt, dull dark blue. Specific gravity, 1·208.	60·	40··	13·5	33·75	Silicate of alumina, lime and oxide of iron.	1·40	·58	·82
Knightswood. — Compact, dull black, massive, with deposits of carbonate of lime and iron pyrites. Principal fracture, slaty, conchoidal; cross fracture, conchoidal. Streak, shining black. Thrown on the fire, decrepitates and flies, but does not fuse. Colour of ash, pale umber, with nitrate of cobalt, dull black.	48·5	51·5	2·4	4·66	Oxide of iron and silicate of lime, with alumina.	1·10	·61	·49
Lesmahago. — Massive, dull black. Principal fracture, slaty, conchoidal; cross fracture, conchoidal and angular. Streak, black and somewhat shining. Thrown on the fire, decrepitates slightly, does not split or fuse. Colour of ash, white; with nitrate of cobalt, dirty blue. Specific gravity, 1·222.	49·6	50·4	9·1	18·05	Silicate of alumina and oxide of iron.	2·23	1·14	1·09
Lochgelly.—Colour, dull black and slaty. Fracture, inclining to slaty; cross fracture, irregular conchoidal. Streak, shining black. On the fire, decrepitates and flies. Ash, white; with nitrate of cobalt, blue. Specific gravity, 1·320.	33·5	66·5	13·1	19·7	Silicate of alumina.	·75	·25	·50

Name and General Character of Cannel.	Volatile Matter.	Coke.	Ash per Cent.		Nature of Ash.	Sulphur in		
			In Coal.	In Coke.		Coal.	Coke.	Volatile Matter.
Old Wemyss.—Compact, dull brownish black; free from foreign matters. Principal fracture, slaty; cross fracture, angular, inclining to conchoidal. Streak, dull brownish black. Thrown on the fire, decrepitates and splits, but does not fly. Colour of ash, dull white; with nitrate of cobalt, olive green. Specific gravity, 1·3256.	52·5	47·5	15·1	31·78	Oxide of iron and silicate of alumina.	1·30	·60	·70
Wigan.—Compact, black and shining. Principal fracture, conchoidal; cross fracture, conchoidal and cubical. Streak, shining black and waxy. Thrown on the fire, decrepitates, flies, and slightly fuses. Colour of ash, yellowish brown, inclining to red; with nitrate of cobalt, olive black. Specific gravity, 1·271.	37·	63·	3·	4·76	Oxide of iron and silicate of alumina.	1·25	.60	·65
Ramsay's Newcastle.—Compact and massive, slightly tinged with oxide of iron. Black and shining. Principal fracture, highly conchoidal and resinoid; cross fracture, conchoidal and cubical. Thrown on the fire, decrepitates and flies to pieces, inclined to fuse. Colour of ash, reddish brown; with nitrate of cobalt, dull black. Specific gravity, 1·290.	36·8	63·2	6·6	10·44	Oxide of iron and silicate of lime, with alumina.	1·75	·94	·81
Band of Cannel in *Leverson's Wallsend Coal.*—This is a dull black band, which runs through the mass of the *coal.* Fracture, slaty, *conchoidal; cross frac-*	30·8	69·2	9·35	13·51	Oxide of iron and silicate of lime, with alumina.	1·00	·50	·50

Name and General Character of Cannel.	Volatile Matter.	Coke.	Ash per Cent.		Nature of Ash.	Sulphur in		
			In Coal.	In Coke.		Coal.	Coke.	Volatile Matter.
ture, cubical and conchoidal. Streak, black and shining. On the fire, splits, but does not fly or fuse. Ash, dull white, with shade of pink; with nitrate of cobalt, dull black. Specific gravity, 1·320.								
Band of Cannel in *Pelton Main Coal.*—Colour dull black, with a shade of brown. Structure, compact and uniform. Fracture, conchoidal and slaty; cross fracture, irregular, conchoidal, with deposits of iron pyrites. Streak, black and shining. On the fire, splits, but does not fly; agglutinates and intumesces slightly. Ash, dirty white, with shade of pink; by nitrate of cobalt, black. Specific gravity, 1·320.	31·5	68·5	9·4	13·72	Oxide of iron and silicate of lime, with alumina.	·95	·49	·46
Band of Cannel in *Washington Coal.*—This resembles Pelton and Leverson's bands. Colour, dull brownish black. Fracture, irregular, conchoidal; cross fracture, cubical and conchoidal. Streak, shining black. On the fire, splits and fuses slightly. Ash, dirty white, with shade of pink. Specific gravity, 1·326.	27·4	72·6	9·37	12·9		1·10	·56	·54
Staffordshire. — Compact and uniform. Fracture, in all directions conchoidal, with deposits of carbonate of lime. Streak, shining black. On the fire, decrepitates and flies, but does not fuse. Ash, dirty white. Specific gravity, 1·220.	50·	50·	2·9	5·8		1·30	·52	·78

Name and General Character of Coal.	Volatile Matter.	Coke.	Ash per Cent.		Sulphur in		
			In Coal.	In Coke.	Coal.	Coke.	Volatile Matter.
NORTHUMBERLAND AND DURHAM: *Blenkinsop.*—Coal black; laminated. Fracture, coarse and granular; cross fracture, splintry, inclining to cubical. Streak, dull black. On the fire, fuses slightly and intumesces. Ash, grey. Specific gravity, 1·298.	38·	62·	5·1	8·22	1·60	·80	·80
Dean's Primrose.—Colour, brownish black, with shining layers. Fracture, in all directions, cubical and somewhat irregular, with occasional deposits of iron pyrites. On the fire, splits, and crackles slightly, swells, and intumesces. Ash, brick red. Specific gravity, 1·261.	29·25	70·75	2·4	3·4	1·40	·71	·69
Garesfield (Butes').—Coal black and rather friable, with thin bands of dark laminæ throughout. Fracture, uneven and cubical; cross fracture, angular and hackley, containing traces of charcoal. Streak, dull black. On the fire, swells and fuses together. Ash, light red. Specific gravity, 1·290.	28·3	71·7	3·2	4·46	·90	·40	·50
Garesfield (Cowan's).—Coal black and shining, with thin dark laminæ. Fracture, irregular and cubical; cross fracture, angular, and affording deposits of charcoal. Streak, dull black. On the fire, agglutinates, swells, and partially fuses. Ash, pale cream colour. Specific gravity, 1·259.	29·4	70·6	·95	1·34	·85	·40	·45
Gosforth.—Coal black, with shining layers. Fracture, irregular, inclining to cubical; cross fracture, cubical, with indications of charcoal. Streak, dull black. On the fire, swells and agglutinates. Ash, dull yellow. Specific gravity, 1·260.	35·	65·	1·	1·54	1·10	·50	·60
Hastings Hartley.—Jet black; laminated and splintry. Fracture, cubical and slightly conchoidal; cross fracture, cubical and irregular. Streak, black, with a shade of brown. On the fire, cracks and splits, with a trifling tendency to agglutinate. Ash, white, with red streaks. Specific gravity, 1·278.	36·6	63·4	2·	3·15	·95	·50	·45

Name and General Character of Coal.	Volatile Matter.	Coke.	Ash per Cent.		Sulphur in		
			In Coal.	In Coke.	Coal.	Coke.	Volatile Matter.
NORTHUMBERLAND AND DURHAM: *West Hartley.*—Jet black, with thin dull laminæ in the direction of the principal fracture, and slight deposits of charcoal. Fracture, slaty, cubical, inclining to conchoidal; cross fracture, cubical, with layers of carbonate of lime. Streak, brown black. On the fire, splits and opens, but does not fuse. Ash, dull cream colour. Specific gravity, 1·269.	35·8	64·2	4·7	7·3	1·10	·60	·50
Leverson's Wallsend.—Colour, coal black, with shining layers. Fracture, cubical, and slightly slaty; cross fracture, cubical, with thin layers of iron pyrites. Streak, black and shining. On the fire, opens out, and agglutinates. Ash, brick red. Specific gravity, 1·278.	34·9	65·1	4·9	7·52	1·30	·65	·65
South Peareth.—Dull black, with bright laminæ, coarse grained. Fracture, irregular, hackley, and inclining to cubical, with charcoal deposits; cross fracture, cubical. Streak, dull black. On the fire, intumesces and fuses partially. Ash, light yellow. Specific gravity, 1·266.	27·8	72·2	1·8	2·5	1·20	·60	·60
Pelaw Main.—Colour, coal black, inclining to jet in variable layers. Fracture, cubical in all directions, with deposits of pyritic charcoal and carbonate of lime. On the fire, opens out, agglutinates, and intumesces. Ash, pale fawn colour. Specific gravity, 1·271.	30·3	69·7	2·6	3·73	1·20	·70	·50
Pelton Main.—Colour, coal black, with shining layers. Fracture, in both directions cubical, with thin deposits of carbonate of lime, and iron pyrites in the cross fracture. Streak, black and shining. On the fire, opens out, and fuses slightly. Ash, pale ochry yellow. Specific gravity, 1·270.	28·4	71·6	1·41	1·96	1·10	·62	·48
New Pelton.—Colour, coal black, inclining to jet in layers. Fracture, slaty and cubical; cross fracture, irregular and cubical. Streak, black and shining. On the fire, opens out, fuses slightly, and intumesces. Ash, light brick red. Specific gravity, 1·265.	30·2	69·8	1·75	2·5	1·10	·56	·54

Name and General Character of Coal.	Volatile Matter.	Coke.	Ash per Cent.		Sulphur in		
			In Coal.	In Coke.	Coal.	Coke.	Volatile Matter.
NORTHUMBERLAND AND DURHAM: *South Tyne.*—Shining black, with dull laminæ. Fracture, somewhat rhomboidal and irregular, with layers of charcoal and pyrites; cross fracture, angular. Streak, dull brownish black. On the fire, agglutinates and swells slightly. Ash, deep pink. Specific gravity, 1·339.	36·3	63·7	3·9	6·1	2·10	1·10	1·00
Urpeth.—Colour, coal black, with shining layers. Fracture, in all directions, cubical, with layers of carbonate of lime and iron pyrites on the cross fracture. Streak, black and shining. On the fire, opens out, swells and fuses slightly. Ash, dull ochry yellow. Specific gravity, 1·271.	28·7	71·3	1·35	1·89	1·00	·60	·40
Washington.—Colour, coal black, with shining layers. Fracture, in all directions, cubical and irregular. On the fire, opens out and fuses slightly. Streak, shining black. Ash, reddish yellow. Specific gravity, 1·260.	31·25	68·75	2·2	3·2	1·30	·67	·63
SOMERSETSHIRE: *Nailsea.*—Dull black, coarse grained and fibrous. Fracture, hackley, inclining to rhomboidal, with numerous deposits of charcoal and iron pyrites; cross fracture, very irregular. Streak, brown black. On the fire, swells and fuses together. Ash, flesh-coloured, with red streaks. Specific gravity, 1·312.	34·9	65·1	3·	4·6	2·85	1·50	1·35
Radstock.—Colour, dull black. Structure, coarse grained and irregular. Fracture, slightly slaty; cross fracture, hackley, inclining to cubical, with layers of charcoal and iron pyrites, in cubical crystals; deposits of carbonate of lime. Streak, dull black. On the fire, alters but little, and intumesces slightly. Ash, dull yellow and flocculent. Specific gravity, 1·275.	38·25	61·75	3·5	5·66	3.10	1·80	1·30
STAFFORDSHIRE: *Apedale, 4 ft.*—Jet black, and in square, splintry fragments. Principal fracture, slaty, and slightly conchoidal; cross fracture, irregular, and numerous black bands. On the fire, decrepitates and opens; does not fuse. Ash, deep fawn colour. Specific gravity, 1·267.	40·	60·	·75	1·25	·80	·38	·42

Name and General Character of Coal.	Volatile Matter.	Coke.	Ash per Cent.		Sulphur in		
			In Coal.	In Coke.	Coal.	Coke.	Volatile Matter.
Staffordshire: *Apedale.*—Jet black and laminated; Splintry and hard. Principal fracture, slaty; cross fracture, irregular and angular, inclining to cubical. Streak, shining black. On the fire, crackles and burns freely, but remains open, without any symptoms of fusion. Ash, deep red. Specific gravity 1·307.	38·5	61·5	1·9	3·1	1·50	·82	·68
Heathern.—Colour, dull black, with shining layers. Fracture, slaty, containing deposits of charcoal; cross fracture, cubical, with thin layers of carbonate of lime and iron pyrites. On the fire, splits and fuses slightly. Ash, pale dull yellow. Specific gravity, 1·280.	42·9	57·1	1·75	3·06	1·50	·70	·80
Silverdale, 10 *ft.*—Splintry and laminated. Principal fracture, slaty; cross fracture, angular, and slightly conchoidal. Streak, dull black. On the fire, splits and crackles slightly; does not fuse. Ash, dull red. Specific gravity, 1·301.	34·	66·	1·95	2·95	1·30	·70	·60
Woodshutts, 7 *ft., Banbury.*—Fibrous and coarse grained. Principal fracture, hackley; cross fracture, irregular, inclining to rhomboidal, with layers of charcoal. On the fire, swells but does not fuse. Ash, deep fawn colour. Specific gravity, 1·291.	40·2	59·8	1·22	2·04	·90	·54	·36
Wales (North): *Ruabon, Top Yard Seam.*—Coal black, with shining layers; laminated. Fracture, slaty and cubical, with charcoal deposits; cross fracture, cubical. Streak, black. On the fire, swells, and agglutinates. Ash, pale fawn colour. Specific gravity, 1·269.	37·5	62·5	2·5	4·	1·40	·80	·60
Ruabon, Main Coal.—Coal black and laminated. Fracture, irregular, inclining to cubical; cross fracture, foliated and splintry, with numerous layers of charcoal, and some indications of iron pyrites. Streak, dull black. On the fire, swells and fuses together. Ash, pale yellow. Specific gravity, 1·284.	41·5	58·5	1·	1·71	·85	·45	·40

Name and General Character of Coal.	Volatile Matter.	Coke.	Ash per Cent.		Sulphur in		
			In Coal.	In Coke.	Coal.	Coke.	Volatile Matter.
WALES (NORTH): *Ruabon, Yard Seam.*—Coal black, with dull laminæ. Fracture, irregular, inclining to cubical; cross fracture, angular, with considerable deposits of charcoal, and thin layers of carbonate of lime. Streak, dull black. On the fire, agglutinates and intumesces. Ash, fawn colour. Specific gravity, 1·271.	34·	66·	1·4	2·12	1·10	·60	·50
Ruabon Nant Seam.—Shining black, and in columnar concretions. Fracture, coarse and hackley, with charcoal deposits; cross fracture, rhomboidal and crystalline, with thin layers of carbonate of lime. Streak, black. On the fire, agglutinates slightly and intumesces. Ash, cream colour. Specific gravity, 1·269.	37·9	62·1	1·4	2·25	1·10	·70	·40
WALES (SOUTH): *Rhonda.*—Colour, coal black. Structure, coarse grained. Fracture, slaty and irregular; cross fracture, hackley and angular. On the fire, swells slightly. Ash, light fawn colour. Specific gravity, 1·278.	22·8	77·2	2·7	3·5	2·30	1·20	1·10
Rhonda Low Main.—Colour, coal black; coarse grained and hackley. Fracture, irregular and slightly cubical; cross fracture, rough and angular. Streak, dull black. On the fire, intumesces and agglutinates feebly. Ash, pale red. Specific gravity, 1·280.	23·1	76·9	2·1	2·73	2·20	1·10	1·10
YORKSHIRE: *Elsecar Low Pit.*—Colour, jet black, with dull layers. Structure, laminated. Fracture, slaty, inclining to cubical; cross fracture, cubical, with numerous deposits of charcoal, and traces of carbonate of lime. Streak, black. On the fire, swells and fuses with some intumescence. Ash, ochry yellow. Specific gravity, 1·258.	37·	63·	1·1	1·74	1·20	·63	·57

Name and General Character of Coal.	Volatile Matter.	Coke.	Ash per Cent.		Sulphur in		
			In Coal.	In Coke.	Coal.	Coke.	Volatile Matter.
Yorkshire: *Grigleston Cliff, Soft.* Colour, coal black. Structure, splintry, and in layers. Fracture, slaty, with bands of charcoal; cross fracture, hackley and cubical, containing traces of carbonate of lime. Streak, black. On the fire, alters but little, and does not fuse or decrepitate. Ash, brick red. Specific gravity, 1·255.	35·6	64·4	1·6	2·48	1·40	·75	·65
Mortomly.—Coal black, with shining layers, in splintry fragments. Fracture, laminated and cubical; cross fracture, cubical and irregular. Streak, dull black. On the fire, splits and opens, but afterwards agglutinates and intumesces. Ash, light fawn colour. Specific gravity, 1·220.	37·	63·	1·6	2·54	1·10	60	·50
Silkston, No. 1.—Colour, jet black. Structure, laminated and prismatic. Fracture, slaty; cross fracture, cubical and irregular, with deposits of carbonate of lime and charcoal. Streak, black and shining. On the fire, splits and fuses slightly. Ash, fawn colour. Specific gravity, 1·260.	34·1	65·9	2·78	4·21	1·30	·80	·50
Silkston, No. 2.—Colour, jet black. Structure, uniform. Fracture, in all directions, cubical; traces of carbonate of lime and charcoal. Streak, brownish black. On the fire, fuses slightly, and intumesces. Ash, yellowish fawn colour. Specific gravity, 1·259.	38·	62·	2·55	4·1	1·10	·60	·50
Silkston, No. 3.—Colour, coal black. Structure, laminated and prismatic. Fracture, slaty and columnar; cross fracture, irregular and cubical, with deposits of charcoal and traces of carbonate of lime. Streak, black. On the fire, alters little. Ash, pale fawn colour. Specific gravity, 1·262.	35·2	64·8	2·8	4·3	1·45	·75	·70
Soap House Pit.—Dull black and slaty, with impressions of leaves. Fracture, rough and hackley, inclining to conchoidal; cross fracture, irregular and angular. On the fire, splits, and then agglutinates and swells. Streak, dull brownish black. Ash, light brown. Specific gravity, 1·258.	35·	65·	·8	1·23	·75	·40	·35

Name and General Character of Coal.	Volatile Matter.	Coke.	Ash per Cent.		Sulphur in		
			In Coal.	In Coke.	Coal.	Coke.	Volatile Matter.
YORKSHIRE: *Woodthorpe.*—Compact, black and uniform in appearance; resembles cannel coal. Fracture, conchoidal; cross fracture, splintry and conchoidal, with layers of carbonate of lime. Streak, black. On the fire, decrepitates slightly and splits, but does not fuse. Ash, dirty pink. Specific gravity, 1·347.	33·1	66·9	10·5	15·7	1·20	·70	·50
FRANCE: *Denain* (*Valenciennes*).—Colour, coal black. Structure, coarse grained and slightly fibrous. Fracture, irregular, inclining to cubical, with layers of charcoal; cross fracture, hackley and angular, with traces of iron pyrites. On the fire, but little affected, intumesces and agglutinates. Ash, fawn colour. Specific gravity, 1·265.	29·9	70·1	6·	8·56	2·40	1·30	1·10

COAL AND CANNEL.

The particulars contained in the following Tables, showing the Producing Power of various kinds of Coal and Cannel, have been derived from the standard works on Gas Lighting, from Parliamentary returns, and from the recorded results of the different experimentalists, in whatever authentic form they may have appeared. There are evident discrepancies between some of the results, especially between the earliest and the most recent. The range of time, however, over which the several experiments have been made, embraces a period of more than fifty years, and it is doubtless to the imperfect apparatus used in the earlier trials that the difference between these and the later results may chiefly be attributed. In some instances the difference is only apparent, the distillatory process having been prolonged at the expense of the illuminating power.

It is exceedingly desirable, in recording the results of experiments with mixtures of various Coals with each other, and along with other substances, that the exact proportions used should be stated. When these are not specified the other particulars given are comparatively valueless. The worth of some of the information contained in the subjoined Tables would have been much enhanced had this necessary rule been followed.

The weight of the coke produced in the different trials should also be given in every instance. The absence of such information, so easily obtained, and of such obvious value, is always to be regretted.

COAL AND CANNEL.

Quantity of Gas obtained from Coal and Cannel per Ton; Illuminating Power of the Gas; Specific Gravity of the Gas; Weight of Coke in Pounds per Ton; and Per Centage of Ash in Coke.

The tests described in the third column of the following tables were made with the old burners, now discarded for the "Standard" burner; it is necessary, therefore, when desiring to ascertain the illuminating power which the latter burner would develop, to add about 15 per cent. to the figures here given.

Name of Coal.	Cubic Feet of Gas Obtained per Ton.	Illum. Power of Gas in Stand. Sperm Cndls.	Specific Grav. of the Gas Air. 1·000.	Wght. of Coke in lbs per Ton.	Ash in Coke per Cent.	Authority.
CANNEL COAL.						
Arniston	12,600	22·5	·626	1221*	7·66*	Chartered Gas Co.
Boghead	13,334	45·		717	..	Mr. T. G. Barlow.
Ditto	15,000	37·75	·752	708*	72·15*	Chartered Gas Co.
Ditto	15,486	52·	·725	760	63·95	Dr. Fyfe.
Bridgewater	11,200	..		..	..	Mr. J. Leigh.
Brymbo	6,650	20·	·504	..	..	
Capeldrae	14,400	19·75	·577	1019*	23·07*	Chartered Gas Co.
Ditto, No. 1	11,500	41·56	·644	999	17·26	Dr. Fyfe.
Ditto, No. 2	9,600	50·	·650	1256	43·7	Ditto.
Chapelside, Airdrie	11,272	35·61		916	19·08	Dr. Wallace, 1869.
Coed Talon, shale	10,780	14·07		Nil.	..	Mr. J. Paterson.
Donibristle	9,923	37·55	·598	1220	7·85	Dr. Fyfe.
Dunkirk, Dukinfield	10,875	22·75		1568	3·	Mr. Longworth.
Haywood, Scotch	11,400	30·22		1157	17·8	Mr. F. J. Evans.
Kirkness	12,800	21·2	562	896*	33·7*	Chartered Gas Co.
Ditto	9,620	..	711	..	..	Dr. Fyfe.
Knightswood	9,720	..	590	..	..	Mr. Wright.
Ditto	13,200	19·	550	1154*	4·66*	Chartered Gas Co.
Ditto	8,950	..	557	..	..	Dr. Fyfe.
Lesmahago, No. 1 Canl.	13,500	27·1	·642	1129*	18·05	Chartered Gas Co.
Ditto, No. 2 do.	13,200	24·8	·618	..	..	Ditto.
Ditto	10,176	44·12	·669	1360	6·58	Dr. Fyfe.
Ditto	12,750	35·55		1052	10·85	Mr. F. J. Evans, 1868.
Ditto	11,500 to 12,000	34·5 to 35·25		1081	11·17	Prof. Penny, 1869.
Ditto, 1st experiment	11,681	..	·540	..	..	Mr. Wright.
Ditto, 2nd do.	9,878	..	·650	..	..	Ditto.
Ditto	11,312	..	·737	..	..	Mr. J. Hedley.
Leverson	11,600	18·	·523	1550*	13·51*	Chartered Gas Co.
Lochgelly	9,123	..	·567	1490*	19·7*	Dr. Fyfe.
Lothian	10,000	..	·556	..	..	Ditto.
Monkland	10,190	..	·667	..	..	Ditto.
New Brunswick	..	..		755	1·78	Mr. L. Thompson.

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* Mr. L. Thompson.

Name of Coal.	Cubic Feet of Gas Obtained per Ton.	Illum. Power of Gas in Stand. Sperm Cndls.	Specific Grav. of the Gas. Air, 1·000.	Wght. of Coke in lbs. per Ton.	Ash in Coke per Cent.	Authority.
CANNEL—*continued.*						
Peasley Cross, St. Helens.	10,000	19·46	..	..	4·25	Mr. King.
Pelton	11,500	18·5	·520	1534*	13·72*	Mr. J. Hedley.
Ramsey	10,300	21·4	·548	..	..	Chartered Gas Co.
Ramsey's Newcastle .	9,746	..	·554 to ·580	..	..	Dr. Fyfe.
Ditto	9,692	16·65	·625	1520	..	Ditto.
Ditto	9,016	..	·604	..	..	Mr. Wright.
Ditto	9,333	..	·598	..	..	MrKay,Dndee.GasCo.
Ditto	9,667	..	·731	..	..	Drs.Leeson,Miller,&c.
Ditto	9,151	27·2	..	1416	10·44	Mr. L. Thompson.
Scotch Parrot . . .	9,500	..	·640	..	..	Dr. Fyfe.
Scotch	14,000	..	·580	..	..	Mr. Clegg.
Ditto	13,813	..	·500	..	..	Ditto.
Staffordshire . . .	..	..	..	1120	5·8	Mr. L. Thompson.
Torryburn	11,200	..	·624	..	..	Dr. Fyfe.
Washington	10,500	18·	·500	1626*	12·9*	Mr. J. Hedley.
Welsh	11,424	..	·737	..	..	Ditto.
Wemyss	10,976	..	·670	..	..	Mr. Wright.
Ditto	10,192	..	·691	..	..	Ditto.
Ditto	14,300	24·5	·580	1064*	31·78*	Mr.Evans,Chrtrd.Co.
Ditto	10,080	..	·642	..	..	Dr. Fyfe.
Wigan	9,500	..	·460 to ·520	..	..	Ditto.
Ditto	11,200	..	·606	..	..	Mr. J. Hedley.
Ditto	9,500	..	·580	..	..	Liverpool Gas Co.
Ditto, Ince Hall . .	11,673	..	·620	1474	..	Mr. J. Leigh.
Ditto, do. . .	11,400	20·	·528	1411*	4·76	Mr.Evans,Chrtrd.Co.
Ditto, Balcarres's . .	11,500	..	..	..	..	Mr. J. Leigh.
Ditto, Blundell's . .	11,500	..	..	..	..	Ditto.
Ditto	9,408	..	·478	..	..	Mr. Wright.
Ditto, Hulton's. . .	10,500	..	..	..	..	Mr. J. Leigh.
Ditto	14,453	..	·640	..	..	Mr. Clegg.
Ditto	14,257	..	·610	..	..	Ditto.
Ditto, Kay & Dewsbury's	11,300	..	..	..	..	Mr. J. Leigh.
Wyan.	14,458	..	·640	..	..	Mr. Clegg.
Yorkshire	11,500	..	·451	..	..	Dr. Fyfe.
Ditto, West Iron & Coal Co., West Ardsley, near Leeds . . .	10,296	21·	..	1344	..	Mr. W. Hugon.
NEWCASTLE COALS.						
Benton Main . . .	10,987	..	·400	..	..	Mr. Clegg.
Berwick & Craister's Wallsend	12,507	..	·470	..	..	Ditto.
Blenkinsopp . . .	11,200	..	·521	..	..	Mr. J. Hedley.
Ditto	9,700	14·	·450	1389	8·22	Mr. L. Thompson.
Dean's Primrose . .	10,500	..	·430	1585	8·4	Ditto.
Ditto	11,120	..	·410	..	..	Mr. Clegg.
Ditto	10,500	12·	·430	..	..	Mr.Evans,Chrtrd.Co.
Eden Main	10,400	..	·400	..	..	Mr. Clegg.

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* Mr. L. Thompson.

Name of Coal.	Cubic Feet of Gas Obtained per Ton.	Illum. Power of Gas in Stand. Sperm Cndls.	Specific Grav. of the Gas. Air, 1·000.	Wght. of Coke in lbs. per Ton.	Ash in Coke per Cent.	Authority.
NEWCASTLE—*con.*						
Ellison's Main . .	11,200	..	·416	..	..	Mr. Clegg.
English caking coal .	8,000	..	·420	..	..	Dr. Fyfe.
Felling Main . . .	11,200	..	·410	...	..	Mr. Clegg.
Garesfield	10,500	..	·398	..	..	Mr. L. Thompson.
Ditto, Bute's . . .	..	..	..	1606	4·46	Ditto.
Ditto, Cowan's . .	..	..	..	1581	1·34	Ditto.
Ditto	10,500	11·5	·398	..	..	Mr. Evans, Chrtrd. Co.
Gosforth	10,000	..	·402	1456	1·54	Mr. L. Thompson.
Ditto	10,000	12·	·402	..	..	Mr. Evans, Chrtrd. Co.
Hasting's Hartley .	10,300	12·5	·421	1420	3·15	Mr. L. Thompson.
Heaton Main . . .	10,400	..	·410	..	..	Mr. Clegg.
Hutton Seam . . .	8,700	..	..	..	..	Hartlepool Gas Co.
Leverson's Wallsend	10,800	..	·425	1458	7·52	Mr. L. Thompson.
Ditto	10,800	12·5	·425	..	..	Mr. Evans, Chrtrd. Co.
Newcastle	11,648	..	·475	..	..	Mr. J. Hedley.
Ditto	9,450	13·5	..	..	..	Brighton Gas Co.
Ditto	9,420	13·5	..	..	..	Brighton and Hove Gas Co.
Ditto	9,395	14·2	..	..	..	Sth. Metropolitan Co.
Ditto	9,200	..	..	..	..	Exeter Gas Co.
New Pelton . . .	10,500	12·	·415	1564	2·5	Mr. L. Thompson.
Peareth's Wallsend .	11,147	..	·410	..	..	Mr. Clegg.
Ditto	9,700	12·	..	..	..	Cambridge Gas Co.
Pelton	11,000	14·	·430	..	..	Mr. Evans, Chrtrd. Co.
Ditto	11,000	14·	·430	1604	1·96	Mr. L. Thompson.
Ditto	11,424	..	·437	..	..	Mr. J. Hedley.
Ditto	9,746	15·93	·555	1563	..	Dr. Fyfe.
Pelaw	11,424	..	·444	..	..	Mr. J. Hedley.
Ditto	11,000	..	·420	..	..	Mr. L. Thompson.
Ditto	11,000	12·75	·420	..	..	Mr. Evans, Chrtrd. Co.
Pelaw Main . . .	12,400	..	·420	1561*	3·78*	Mr. Clegg
Russell's Wallsend .	12,000	..	·418	..	..	Ditto.
South Pelaw . . .	9,000	12·5	..	..	..	Rochester Gas Co.
South Peareth . .	..	..	..	1617	2·5	Mr. L. Thompson.
South Tyne . . .	..	..	..	1427	6·1	Ditto.
Urpeth	..	..	..	1597	1·89	Ditto.
Wallsend, Newcastle	12,000	..	·490	..	..	Revolving Web Retort.
Washington . . .	10,000	14·	·430	1540	3·2	Mr. L. Thompson.
West Hartley . . .	10,500	12·5	·420	1438	7·3	Ditto.
CUMBERLAND, YORKSHIRE, LANCASHIRE, DERBYSHIRE, STAFFORDSHIRE, WELSH, AND OTHER KINDS OF COAL.						
Arley	10,200	13·	·462	1540	6·	Mr. J. E. Clift.
Ditto	..	..	..	1485	5·43	Mr. L. Thompson.
Ditto	11,200	13·8	·406	1460	..	Dr. Thompson.
Ashton-under-Lyme coal slack . . .	9,000	10·	..	..	..	Stafford Gas Co.
Barley Brook, Arley, Wigan	9,500	16·7	·460	1459	4·59	Mr. Alfred King.

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* Mr. L. Thompson.

Name of Coal.	Cubic Feet of Gas Obtained per Ton.	Illum. Power of Gas in Stand. Sperm Cndls.	Specific Grav. of the Gas. Air, 1·000.	Wght. of Coke in lbs. per Ton.	Ash in Coke per Cent.	Authority.
VARIOUS COALS—*con.*						
Bickerstaff, Liverpool	11,424	..	·475	..	..	Mr. J. Hedley.
Bilston	7,100	9·5	..	..	..	Bilston Gas Company.
Brancepeth	8,500	18·	..	..	..	Harrogate Gas Co.
Brymbo, 2-yard coal .	8,800	..	·468	..	..	Mr. Wright.
Ditto, main	10,500	15·	·540	..	..	Mr. L. Thompson.
Cheshire.	..	..	..	1584	7·8	Ditto.
Cumberland, No. 1 .	..	..	..	1669	2·81	Ditto.
Ditto, No. 2 .	..	..	..	1667	1·88	Ditto.
Ditto, No. 3 .	..	..	..	1548	5·8	Ditto.
Derbyshire	8,000	18·	..	..	..	Leamington Gas Co.
Ditto	8,500	18·	..	..	..	Leicester Gas Co.
Ditto	8,500	15·	..	..	..	Oxford Gas Co.
Ditto, Staveley. . .	..	..	..	1824	4·57	Mr. L. Thompson.
Ditto, deep main . .	9,400	..	·424	..	..	Mr. Wright.
Ditto, soft coal. . .	7,500	..	·528	..	..	Leicester Gas Co.
Ditto, do. . . .	7,000	..	·448	..	..	Derby Gas Co.
Ditto, do. . . .	7,000	..	·424	..	..	Nottingham Gas Co.
Durham Fields, best seam	8,600	12·	..	..	..	Sunderland Gas Co.
Forest of Dean, 1st var.	10,188	..	·850	..	..	Mr. Clegg.
Ditto, 2nd variety . .	10,188	..	·860	..	..	Ditto.
Ditto	9,000	8 to 9	..	..	..	Gloucester Gas Co.
France, Denain (Valenciennes) . . .	..	..	..	1570	8·56	Mr. L. Thompson.
Garswood Hall topcoal Wigan	10,820	16·	·566	1846	5·79	Mr. J. Paterson.
Gloucestershire, Coal-Pit Heath . . .	..	..	..	1566	8·8	Mr. L. Thompson.
Glo'stershire, Whitecroft, near Lydney .	..	..	..	1472	16·89	Mr. L. Thompson.
Hindley Field bestcoal	10,760	15·26	·450	1814	5·45	Mr. J. Paterson.
Leeds coal	6,500	..	·580	..	..	Leeds Gas Co.
Llanelly, Wales . .	5,000 to 8,000	..	..	..	..	Llanelly Gas Co.
Lumpcoal, Westbromwich	6,500	..	·453	..	..	Birmingham Gas Co.
Ditto, do. . .	6,500	..	·455	..	..	Birmingham and Staffordshire Gas Co.
Macclesfield . . .	6,720	..	..	..	..	
Mynydd Bach-y-Glo-Colliery coal . . .	7,000	9·	..	..	..	Swansea Gas Co.
Neath, South Wales .	11,200	..	·468	..	..	Mr. J. Hedley.
Ormskirk or Wigan slack	8,200	..	·462	..	..	Liverpool Old Gas Co.
Park Gate Coal . .	7,500	11·	..	..	..	Rotherham Gas Co.
Platt Lane Coal . .	9,750	18·75	·488	1412	2·94	Mr. J. Paterson.
Powell coal, 2 cwt. charges every 5 hours	10,165	..	·459	..	..	Mr. Wright.
Powell coal, 1½ cwt. charges every 5 hours	8,250	..	·470	..	..	Ditto.
Somersetshire coal .	8,000	..	..	..	..	Wells Gas Co.
Ditto, Nailsea . . .	..	..	..	1458	4·6	Mr. L. Thompson.
Ditto, Radstock . .	..	..	..	1888	5·66	Ditto.
Staffordshire, Apedale	..	..	..	1878	8·1	Ditto.
Ditto, 4 feet do. .	..	..	..	1844	1·25	Ditto.

Name of Coal.	Cubic Feet of Gas Obtained per Ton.	Illum. Power of Gas in Stand. Sperm Cndls.	Specific Grav. of the Gas. Air, 1·000.	Wght. of Coke in lbs. per Ton.	Ash in Coke per Cent.	Authority.
VARIOUS COALS—*con.*						
Staffordshire, Heathern	..	..	..	1279	3·06	Mr. L. Thompson.
Ditto, Silverdale, 10-ft.	..	..	..	1478	2·95	Ditto.
Ditto, Woodshuts, Banbury, 7-feet . .	..	..	..	1340	2·04	Ditto.
Ditto	7,730	11to12	..	..	..	Bath Gas Co.
Ditto, South, 1st var.	10,933	..	·398	..	..	Mr. Clegg.
Ditto, 2nd do.	10,667	..	·395	..	..	Ditto.
Ditto, 3rd do.	10,667	..	·390	..	..	Ditto.
Ditto, 4th do.	9,600	..	·320	..	..	Ditto.
St. Helens	..	..	..	1407	1·91	Mr. L. Thompson.
Stockport	7,800	..	·539	..	..	Stockport Gas Co.
Wales (North), Ruabon, top yard seam	..	..	..	1400	4·	Mr. L. Thompson.
Ditto, main coal . .	..	..	..	1310	1·71	Ditto.
Ditto, yard seam . .	..	..	..	1478	2·12	Ditto.
Ditto, Nant seam . .	..	..	..	1391	2·25	Ditto.
Wales (South), Rhonda	..	..	..	1729	3·5	Ditto.
Ditto, low main . .	..	..	..	1723	2·73	Ditto.
Ditto, Neath . . .	11,200	..	·468	..	..	Mr. J. Hedley.
Welsh coal, 1st variety	10,000	..	·385	..	..	Mr. Clegg.
Ditto, 2nd do.	10,133	..	·380	..	..	Ditto.
Wigan and St. Helens caking coal . . .	9,168	16·25	..	..	..	Mr. J. Paterson.
Yorkshire, best South	9,000	14·	..	..	..	Sheffield Gas Co.
Ditto, Elsecar Low Pit	..	..	..	1411	1·74	Mr. L. Thompson.
Ditto, Grigleston Cliff, soft	..	..	..	1443	2·48	Ditto.
Ditto, Mortomly . .	..	..	..	1411	2·54	Ditto.
Ditto, Silkstone . .	8,600	13·3	..	..	..	Great Grimsby Gas Co.
Ditto, Silkstone, No. 1	..	..	..	1476	4·21	Mr. L. Thompson.
Ditto, Silkstone, No. 2	..	..	..	1389	4·1	Ditto.
Ditto, Silkstone, No. 3	..	..	..	1452	4·3	Ditto.
Ditto, Silkstone, nuts, Thorncliffe . . .	10,800	15·85	..	1418	6·	Mr. F. J. Evans, 1870.
Ditto, Soap House Pit	..	..	..	1456	1·23	Mr. L. Thompson.
Ditto, Woodthorp .	..	..	..	1499	15·7	Ditto.
MIXTURES OF CANNEL AND COAL.						
Proportions specified.						
Boghead cannel 1-8th, Arley Mine coal 7-8ths	10,400	16·5	..	..	..	Blackburn Gas Co.
Boghead cannel 5 per cent., Newcastle coal 95 per cent.	10,000	14·	..	..	..	Devonport Gas Co.
Boghead cannel 1-4th, Pelton coal 3-4ths .	12,800	..	..	..	..	Mr. T. G. Barlow.
Boghead cannel 1-10th Lochgelly cannel 9-10ths	9,055	24·93	..	..	..	Ditto.

Name of Coal.	Cubic Feet of Gas Obtained per Ton.	Illum. Power of Gas in Stand. Sperm Cndls.	Specific Grav. of the Gas. Air, 1·000.	Wght. of Coke in lbs. per Ton.	Ash in Coke per Cent.	Authority.
MIXTURES OF CANNEL AND COAL.—*con.*						
Drighlington cannel 1-4th, Halifax soft bed coal 3-4ths . .	9,000	18·9	..	..	..	Shipley Gas Company.
Ince Hall cannel 68 per cent., Arley coal slack 32 cent. . .	10,206	19·01	·527	1396	6·4	Rossendale Union Gas Co.
Lesmahago cannel 6 per cent., Cumberland coal 94 per cent.	7,000	15·	..	..	..	Carlisle Gas Co.
Wigan coal and iron Co.'s cannel 72 per cent., Arley coal slack 28 per cent. .	9,967	19·65	·530	1462	5·2	Rossendale Union Gas Co.
Wigan cannel 2-3rds, coal 1-3rd	9,600	17·	..	..	..	Heywood Gas Co.
Cannel and Newcastle coal 1 to 5. . . .	9,000	14·	..	..	..	Alliance Gas Co., Dublin.
Half cannel coal, half black bed	9,000	16·	..	..	..	Pudsey Gas Co.
Half cannel, half coal.	9,450	13·5	..	..	..	St. Helens Gas Co.
Proportions not specified.						
Wigan cannel and other coals . . .	10,091	21·	..	..	..	Birkenhead Gas Co.
Cannel and bett or bed coals	9,250	18·	..	..	..	Bradford Gas Co.
Ramsey's cannel with Newcastle caking coal	9,500 to 10,000	12·	..	..	..	Hastings Gas Co.
Cannel and best house coal.	9,000	12to14	..	..	..	Holmfirth Gas Co.
Cannel and Newcastle coal.	9,300	12·5	..	..	..	Phœnix Gas Co.
Ditto do. .	9,400	12·	..	..	..	Plymouth and Stonehouse Gas Co.
Ditto do. .	8,000 to 9,000	12·	..	..	..	Portsea Island Gas Co.
West Riding cannel and common coal .	8,000	10to14	..	..	..	Scarborough Gas Co.
Oldham, Watergate, and Wigan cannel .	9,500	..	·534	..	..	Manchester Gas Co.
MIXTURES OF DIFFERENT COALS.						
Coal-Pit Heath, Forest of Dean and South Wales	7,000	13·	..	..	...	Bristol Gas Co.
Derbyshire and Staffordshire coal . .	8,500	10to12	..	..	..	Warwick Gas Co.
Ditto do. .	9,000	9to 10	..	..	..	Worcester Gas Co.
Derbyshire, Nottinghamshire, and Yorkshire best coal .	7,800 to 8,200	12to15	..	..	..	Nottingham Gas Co.

Name of Coal.	Cubic Feet of Gas Obtained per Ton.	Illum. Power of Gas in Stand. Sperm Cndls.	Specific Grav. of the Gas. Air, 1·000.	Wght. of Coke in lbs. per Ton.	Ash in Coke per Cent.	Authority.
MIXTURES OF DIFFERENT COALS—*con.*						
Derbyshire and Forest of Dean Coal . .	9,000	10·	..	..	..	Cheltenham Gas Co.
Low Moor mixed with two kinds of slack .	8,000	..	·420	..	..	Bradford Gas Co.
New Pelton and other Newcastle coals. .	8,500	13·	..	..	..	Kingston-on-Thames Gas Co.
Newport (Monmouthshire) and Somersetshire coals . . .	Newp'rt 8,000 Somers. 5,500	9·	..	..	..	Weston-super-Mare Gas Co.
Ravensworth Pelaw & Newcastle coals .	9,000	13·	..	..	..	Beccles Gas Co.
Silkstone and Renshaw coal. . . .	7,500	11·5	..	..	..	Lincoln Gas Co.
South Wales and Bristol coal	7,500	..	..	..	..	Bridgewater Gas Co.
Staffordshire and Derbyshire coal . . .	8,800	12·5	..	..	..	Birmingham Gas Co.
MIXTURES OF COAL AND OTHER SUBSTANCES.						
Llantwit small coal, with 5 per cent. of Broxbourne shale oil	9,750	21·5	..	..	..	Mr. T. G. Barlow.
Newcastle coal 80 per cent., Trinidad bitumen 20 per cent. .	10,600	17·6	..	..	..	Dr. Letheby and Mr. Keates.
Newcastle coal 90 per cent., Trinidad bitumen 10 per cent. .	10,200	15·6	..	..	..	Ditto do.
New Brunswick Albertite.	9,166 to 10,200	28·66 to 35·42	..	..	..	Mr. Evans.

RECENT ANALYSIS OF COALS AND CANNELS.

Name of Coal.	GAS.				COKE.		Authority.
	Gas per Ton of Coals. Cubic Feet.	Illuminating Power. Candles.	Absorption by Bromine per Cent.	Carbonic Oxide per Cent.	Per Ton of Coals. lbs.	Ash in Coke. per Cent.	
CANNELS.							
Boghead	13,000	40·00	25·0	1·5	670	60·0	Mr. F. J. Evans
Lesmahago	12,000	32·00	14·0	3·0	980	7·0	"
Lothian Cannel . .	12,700	34·00	17·0	7·0	963	6·0	"
Cleugh Cannel. . .	12,000	30·00	7·75	10·5	1182	12·8	"
Lochgelly	10,500	17·00	40·00	6·0	1232	15·0	"
Ince Hall (Wigan) .	10,200	20·00	12·00	3·5	1120	8·0	"
Wigan	10,000	20·00	13·00	4·2	1120	6·5	"
Kirkless Hall . . .	10,500	23·00	14·00	4·0	1232	9·5	"

Name of Coal.	GAS.				COKE.		Authority.
	Gas per Ton of Coals. Cubic Feet.	Illuminating Power. Candles.	Absorption by Bromine per Cent.	Carbonic Oxide per Cent.	Per Ton of Coals. lbs.	Ash in Coke. per Cent.	
CANNELS—*continued.*							
Leeswood Curley . .	10,000	28·0	24·0	8·0	728	10·0	Mr. F. J. Evans
Ditto do. average	9,800	20·0	12·5	8·0	1120	8·0	„
Wemyss	11,000	26·0	17·0	1·0	1344	50·0	„
VARIOUS COALS.							
Pelton (Old). . . .	11,500	13·5	5·0	5·0	1560	2·75	„
„ (New) . . .	10,500	12·0	4·75	4·5	1568	2·50	„
Pelaw	10,000	13·25	4·5	4·5	1568	2·50	„
Waldridge	9,000	13·0	4·3	3·5	1568	3·00	„
Wearmouth. . . .	10,500	13·5	4·7	3·8	1500	2·50	„
Bute's Tanfield . .	10,100	13·5	4·0	3·7	1450	3·80	„
Dean's Primrose . .	10,500	13·5	5·0	4·7	1400	3·50	„
South Hetton . . .	9,600	12·7	3·0	3·2	1470	3·70	„
Shincliffe	9,500	12·0	5·0	2·0	1500	3·80	„
Lambton	10,500	14·0	4·3	3·3	1560	2·80	„
Haswell	10,300	13·0	3·4	3·1	1300	2·50	„
Silkstone, three samples. . . .	10,400	15·64	6·25	6·25	1336	3·00	„
	10,866	15·84	6·5	6·25	1377	2·00	„
	10,800	15·65	4·75	7·0	1480	6·10	„
Thorncliffe	10,500	16·5	5·5	6·5	1433	4·80	„
Rhos Lantwit, Caerphilly	9,730	15·07	7·3	8·2	..	..	Mr. Fiddes.
Ditto do. . .	9,675	13·69	4·55	7·3	..	..	„
Powell's Lantwit, large	11,079	15·16	6·05	10·1	..	..	„
Ditto do. small	10,285	14·56	5·0	8·6	..	..	„
Lydney — Norchard Coal— Coleford, High Delf Seam	9,215	15·46	4·75	10·3	..	..	„
Ditto do. . . .	8,702	14·13	4·25	9·4	..	..	„
Cannel—Vartez Hill Colliery, Pontypool	9,262	17·21	6·2	8·6	..	..	„
Gas Coal from do. .	9,021	15·47	5·8	4·9	..	..	„
Tyr Filkens, Newport, Mon.	11,835	13·6	4·3	5·9	..	..	„
Lydney — Tranchard Seam	9,870	14·77	5·45	8·6	..	..	„
Pellowell, near Lydney	9,785	13·84	4·25	10·15	..	..	„
Llantwit Red Ash, Pontypridd small coal	9,390	15·06	5·8	8·9	..	..	„
Ditto do. large	9,708	16·33	6·46	8·33	..	..	„
Dean's Primrose . .	9,800	16·0	..	..	..	..	Mr. G. Livesey
Holmside	9,800	16·0	..	..	..	..	„
West Leversons . .	9,464	15·5	..	..	..	..	„
Townley	9,200	15·3	..	..	..	..	„
Washington . . .	9,200	16·9	..	..	..	..	„
Nettlesworth Primrose.	9,500	..	..	..	..	..	„
West Pelaw. . . .	9,537	..	..	..	..	..	„
Norfolk Silkstone . .	10,000	17·5	..	..	..	..	„
Teesdale.	9,468	..	..	..	..	..	„

RECENT ANALYSIS OF COALS AND CANNELS—*continued.*

Name of Coal.	Specific Gravity.	Gas per Ton in Cubic Feet.	Illuminating Power of Gas in Standard Candles.	Value of One Cubic Foot of Gas in Grains of Sperm.	Value of One Ton of Coal in lbs. of Sperm.	Coke per Ton of Coal in lbs.	Ash in Coal per Cent.	Sulphur in Coal per Cent.	Hydro-carbons absorbed by Bromine per Cent.	Authority.
CANNELS.										
Adwalton Stone Coal, Seam No. 1	1·287	11,350	22·24	..	865·45	1308	5·9	..	12·20	Hutchinson Brothers.
Ditto, Seam No. 2	1·34	10,665	20·21	..	739·13	1400	10·10	..	11·20	Ditto.
Billyford	1·264	9,622	25·31	607	836	1140	6·21	0·28	13·00	Dr. Macadam.
Blackhall and Calderbank, No. 2	..	10,200	26·30	607	876	1264	6·58	1·00	9·80	Mr. G. F. Cusiter.
Braehead	..	10,033	27·06	648	930	1267	16·00	..	11·6	Mr. G. R. Hislop.
Coppa Curly	..	12,600	42·60	..	..	1370	..	..	..	Mr. G. H. Birkbeck.
Ditto, Smooth	..	9,200	32·30	..	..	1310	..	..	..	Ditto.
Cornsilloch and Milburn	1·243	11,600	25·68	616	973	1102	1·73	0·68	10·13	Mr. G. R. Hislop.
Cowdenbeath	1·283	10,280	24·16	579	851	1312	4·74	0·43	..	Dr. Macadam.
Craignethan	1·236	12,459	31·54	757	1347	1119	4·88	0·83	..	Mr. G. R. Hislop.
Donibristle	1·264	10,260	27·50	660	967	1408	4·84	0·34	12·0	Dr. Macadam.
Dykehead	1·286	9,040	24·11	578	..	1235	4·03	0·27	9·0	Mr. G. R. Hislop.
Eglinton	1·412	9,398	25·45	610	820	1394	23·50	0·58	10·25	Ditto.
Fortisset	1·514	10,311	23·18	550	819	1293	9·63	1·19	8·5	Ditto.
Greenhill	1·370	9,340	38·00	912	1204	1308	26·96	0·96	16·0	Mr. G. F. Cusiter.
Home Farm and Bog Parrot	1·280	10,000	24·00	576	822	1286	10·00	0·787	10·0	Ditto.
Inchall	1·277	13,520	32·72	785	1518	1026	11·82	0·62	17·25	Ditto.
Kirkness	1·264	13,825	32·13	771	1522	1034	11·50	0·91	16·25	Ditto.
Kirkwood, No. 1	..	11,615	30·04	722	1196	1002	5·61	0·58	13·75	Ditto.
Lanemark	1·286	11,000	29·37	..	..	1190	..	1·61	10·70	Mr. F. J. Evans.
Lesmahago, Duke of Hamilton	1·217	12,200	34·80	835	1455	1070	4·72	0·746	17·00	Mr. G. F. Cusiter.
Lochore	1·214	13,100	36·01	864	1617	980	10·56	0·82	19·00	Dr. Macadam.
Merryton	1·256	9,460	22·84	548	740	1271	8·57	0·60	8·75	Mr. G. R. Hislop.

Name of Coal.	Specific Gravity.	Gas per Ton in Cubic Feet.	Illuminating Power of Gas in Standard Candles.	Value of One Cubic Foot of Gas in Grains of Sperm.	Value of One Ton of Coal in lbs. of Sperm.	Coke per Ton of Coal in lbs.	Ash in Coal per Cent.	Sulphur in Coal per Cent.	Hydro-carbons absorbed by Bromine.	Authority.
CANNELS—*continued*.										
Monkland	1·218	13,100	32·60	782	..	1127	5·70	0·70	15·50	Mr. G. F. Cusiter.
Muirkirk, No. 1	1·226	12,160	32·54	781	1356	1125	2·44	0·51	15·25	Mr. G. R. Hislop.
Orrell Nuts	1·234	11,150	14·22	..	..	1441	3·14	1·67	..	Mr. R. Betley.
Old Wemyss	1·230	12,896	31·75	762	1404	1136	15·40	1·32	14·00	Mr. G. F. Cusiter.
Ramsey's Newcastle Cannel	..	12,000	28·00	..	..	..	9·06	0·71	..	Mr. J. Pattinson.
Rosehall	1·320	9,340	28·47	683	911	1336	11·68	0·54	11·00	Mr. G. F. Cusiter.
Seton Parrot	1·250	10,460	22·05	529	790	1077	2·67	0·49	11·00	Dr. Macadam.
Stane (Shotts)	1·337	10,294	23·11	..	..	..	..	..	6·30	Mr. J. Hislop.
Sunybank	..	11,933	30·48	..	..	1344	12·40	0·87	12·00	Mr. F. M. Remington.
Tannochside	1·257	10,913	28·32	680	1060	1250	4·50	0·74	12·50	Mr. G. R. Hislop.
Woodbank	1·240	12,000	36·50	924	1584	1088	16·00	1·72	19·00	Mr. G. F. Cusiter.
COALS.										
Barnsley "Soft Coal"	1·263	10,250	17·00	..	597	1410	1·75	..	5·1	Mr. J. Hutchinson.
Bromley Silkstone	1·268	11,012	16·48	..	621	1400	1·44	..	4·8	Ditto.
Framwellgate "Busty Seam"	..	11,099	14·40	..	..	1512	2·83	0·82	..	Mr. J. Pattinson.
Hebburn Main	..	10,059	15·40	..	..	1520	..	..	..	Ditto.
Hoyland Silkstone	1·273	10,520	15·96	..	..	1350	1·90	..	4·3	Mr. J. Hutchinson.
Liversedge	..	10,767	18·70	..	689	1578	6·88	..	5·0	Mr. W. Carr.
Middleton "Soft Gas Coal"	1·272	10,365	16·74	..	..	1375	2·87	..	5·7	Hutchinson Brothers.
Pindar Oaks Gas Coal	1·268	10,360	17·08	..	606	1372	..	..	5·0	Mr. J. Hutchinson.
Silkstone (Real Old) Gas Coal	1·269	11,800	16·75	..	677	1450	1·38	..	5·0	Ditto.
Stanhope Silkstone Main	..	10,620	17·56	..	..	1476	..	..	..	Mr. A. Upward.
Wigan Deep Yard Gas Coal	1·283	9,100	17·40	..	..	1523	5·79	..	..	Mr. W. King.
Wigan, Arley Mine	1·279	9,780	18·30	..	..	1500	2·29	..	..	Ditto.

RECENT ANALYSIS OF COALS AND CANNELS—*continued.*

COALS. (F. J. Evans.)

Name of Coal.	Gas perTon in Cubic Feet.	Illuminating Power of Gas.	Value of One Cubic Foot in Grains of Sperm.	Coke per Ton of Coal. lbs.	Sulphur in Coal per Cent.	Hydrocarbons condensed by Bromine.	Value of One Ton in lbs. of Sperm.
Old Pelton	11,500	14·50	348	1545	·75	5·0	571
Pelaw	11,500	14·75	354	1568	·85	4·5	581
Washington . . .	10,000	15·00	360	1523	·73	5·0	514
New Pelton . . .	10,100	14·00	336	1456	·62	4·75	484
Leverson	11,000	14·00	336	1411	·69	4·00	528
Dean's Primrose . .	10,500	15·00	360	1456	·90	4·80	540
Londonderry . . .	9,800	16·50	396	1545	1·64	6·50	554
Do. average of eight samples	11,000	16·80	403	1500	1·30	6·00	633
Gosforth	10,000	13·50	324	1456	1·10	4·00	462
West Hartley . . .	10,800	14·00	336	1411	1·20	4·20	518
Hastings Hartley . .	10,300	14·00	333	1344	1·50	4·30	494

CANNELS. (F. J. Evans.)

Name of Cannel.	Gas per Ton.	Condensed per Cent. by Bromine.	Specific Gravity of Gas.	Specific Gravity of Condensed Matter.	Photogenic Power.	
					Actual.	By Analysis.
Boghead	15,000	30·0	·752	1·21	35·75	36·30
Lesmahago, No. 1	13,500	16·0	·642	1·64	27·10	26·24
Ditto No. 2	13,200	17·0	·618	1·43	24·80	24·31
Capeldrae	14,400	16·5	·577	1·29	19·75	21·28
Armiston	12,600	17·0	·626	1·40	22·50	23·80
Ramsey	10,300	12·5	·548	1·82	21·40	22·95
Wemyss	14,300	14·5	·580	1·87	24·50	27·11
Kirkness	12,800	10·2	·562	1·95	21·20	19·88
Knightswood	13,200	9·6	·550	2·28	19·00	21·66
Wigan (Ince Hall) . . .	11,400	11·5	·528	1·77	20·00	20·35

RECENT ANALYSIS OF COALS AND CANNELS—*continued.*

COALS. (Mr. W. Fiddes.)

Illuminating Power ascertained by the New "London" Argand.

Name of Coal.	Specific Gravity.	Gas per Ton in Cubic Feet.	Illuminating Power of Gas.	Value of one Cubic Foot of Gas in Grains of Sperm.	Value of Gas per Ton of Coal in lbs. of Sperm.	Coke per Ton of Coal in lbs.	Ash in Coal per Cent.	Sulphur in Coal per Cent.	Hydro-carbons absorbed by Bromine per Cent.
Welsh Coals.									
Llantwit	1·271	10,285	16·56	397	583	1524	4·85	1·42	5·00
Ditto	1·277	11,079	17·16	411	650	1522	4·05	1·42	6·05
Ditto	..	11,092	16·38	393	623	..	..	..	..
Rhos Llantwit	1·282	9,730	17·07	409	568	1417	2·332	1·643	..
Ditto	1·302	9,900	16·86	404	571	1411	2·876	2·312	5·71
Ditto	1·302	9,675	15·69	376	519	1462	4·043	2·414	4·55
Llantwit Red Ash	1·272	9,708	18·33	439	609	1344	4·900	1·354	6·46
Ditto do.	1·227	9,390	17·06	409	549	1305	9·850	1·340	5·30
Ditto do.	..	9,180	15·94	382	501	..	..	..	..
Llantwit Basin	..	8,325	16·92	406	482	..	..	..	..
Ditto do.	..	7,300	16·76	401	418	..	..	..	..
Nantgarw Llantwit	1·326	9,791	16·64	399	558	1379	3·780	3·450	5·20
Bargoed	..	8,600	15·86	380	467	..	..	..	..
Cwmserchan	..	10,350	15·19	364	538	..	..	..	..
Rock Vein	..	9,399	18·52	444	596	..	6·42	..	..
Ditto	..	8,370	17·44	418	499	..	..	..	..
Varteg Hill Cannel	1·467	9,262	19·21	461	609	1366	8·33	2·32	6·20
Ditto Gas Coal	1·302	9,021	17·47	419	539	1335	9·12	2·32	5·30
Ditto do.	..	8,010	15·07	361	413	..	..	..	..
Ditto do.	..	10,080	15·65	375	540	..	6·70	..	..
New Tredegar	1·288	9,910	14·30	343	485	1715	1·615	3·200	4·33
Ditto	..	9,321	14·09	338	450	..	..	..	..
Energlyn	1·312	9,960	17·85	428	609	1597	2·30	1·87	5·75
Ditto	..	10,464	15·36	368	550	..	..	..	..
Aberbege	..	8,885	17·02	408	518	..	..	..	..
Holly Bush	1·269	10,577	12·51	300	453	1666	3·502	2·279	3·10

Name of Coal.	Specific Gravity.	Gas per Ton in Cubic Feet.	Illuminating Power of Gas.	Value of one Cubic Foot of Gas in Grains of Sperm.	Value of Gas per Ton of Coal in lbs. of Sperm.	Coke per Ton of Coal in lbs.	Ash in Coal per Cent.	Sulphur in Coal per Cent.	Hydrocarbons absorbed by Bromine per Cent.
Welsh Coals—*continued.*									
Abercarn	..	12,300	15·97	383	673	..	..	..	..
Rhondda Valley	..	10,270	11·04	265	389	..	..	..	..
Tyr Filkens	1·368	11,835	15·60	374	632	1452	3·008	2·587	4·30
Blenavon	..	10,519	15·43	370	556	..	4·780	..	..
Blendare	..	7,755	17·66	424	469	..	..	..	..
Llanhilleth	1·274	9,480	16·43	394	533	1676	1·810	1·090	..
Aber Rhondda	1·320	9,680	14·00	336	464	1585	0·805	3·075	2·71
Wallsend	1·317	9,990	17·84	428	611	1478	4·820	1·800	6·10
Pontygwaith	..	8,890	15·53	372	472	..	5·720	..	..
Brynooch	1·285	10,971	16·17	388	608	1585	1·830	..	4·00
Ditto	1·369	9,349	15·44	370	494	1491	13·120	..	4·30
Gloucestershire Coals.									
Coleford High Delf	1·210	9,700	17·46	419	580	1428	3·020	2·002	4·75
Ditto do.	1·354	9,785	15·84	380	531	1351	10·235	2·607	4·25
Ditto do.	1·381	9,630	15·35	368	506	1338	9·210	2·370	4·40
Ditto do.	1·313	9,150	16·13	387	506	1402	6·700	1·009	4·25
Trenchard's Lydney	1·354	9,870	16·77	402	567	1410	4·800	1·271	5·45
New Bowson, Cinderford	1·332	9,220	17·80	427	562	1308	4·760	1·940	5·20
Ditto do.	1·307	8,576	16·80	403	494	1320	4·230	0·850	4·98
Hanham	1·277	9,979	14·37	345	492	1318	11·480	2·440	4·75
Ditto	..	9,465	14·82	355	480	1416	7·420	..	4·00
Ditto	..	8,329	14·61	350	417	1416	9·500	..	4·00
Yate	..	10,360	15·61	374	553	..	5·980	..	..
Ditto	..	9,900	13·55	325	459	..	3·480	..	..
Coal Pit Heath	..	8,262	18·18	436	516	..	13·740	..	..
Ditto	..	8,800	16·70	400	503	..	..	..	..
Ditto	..	13,871	15·24	366	723	..	..	..	..
Ditto	..	7,500	15·00	360	386	..	..	..	..
Warmley	1·304	8,990	15·50	372	478	1598	5·880	0·370	4·95
Parkfield	1·374	9,012	19·30	463	596	1305	3·580	1·437	5·25

RECENT ANALYSIS OF COALS AND CANNELS—*continued.*

COALS. (Mr. W. Fiddes.)

Illuminating Power ascertained by the New "London" Argand.

Name of Coal.	Specific Gravity.	Gas per Ton in Cubic Feet.	Illuminating Power of Gas.	Value of one Cubic Foot of Gas in Grains of Sperm.	Value of Gas per Ton of Coal in lbs. of Sperm.	Coke per Ton of Coal in lbs.	Ash in Coal per Cent.	Sulphur in Coal per Cent.	Hydro-carbons absorbed by Bromine per [illegible]
Welsh Coals.									..
Llantwit	1·271	10,285	16·56	397	583	1524	4·85	1·42	..
Ditto	1·277	11,079	17·16	411	650	1522	4·05	1·49	..
Ditto	..	11,092	16·88	393	623	..	..	..	..
Rhos Llantwit	1·282	9,730	17·07	409	568	1417	2·332	..	..
Ditto	1·302	9,900	16·86	404	571	1411	2·876	..	..
Ditto	1·302	9,675	15·69	376	519	1462	4·048	..	..
Llantwit Red Ash	1·272	9,708	18·33	439	609	1844	4·90	..	..
Ditto do.	1·227	9,390	17·06	409	549	1305	9·9	..	..
Ditto do.	..	9,180	15·94	382	501	..	.	..	..
Llantwit Basin	..	8,325	16·92	406	482	..	..	..	..
Ditto do.	..	7,300	16·76	401	418	..	..	..	..
Nantgarw Llantwit	1·326	9,791	16·64	399	558	1879	3·68	2·37	4·35
Bargoed	..	8,600	15·86	380	467	..			
Cwmserchan	..	10,350	15·19	364	538	..			
Rock Vein	..	9,399	18·52	444	596	.			
Ditto	..	8,370	17·44	418	499				
Varteg Hill Cannel	1·467	9,262	19·21	461	609				
Ditto Gas Coal	1·302	9,021	17·47	419	539				
Ditto do.	..	8,010	15·07	361	418				
Ditto do.	..	10,080	15·65	375	540				
New Tredegar	1·288	9,910	14·30	343	4[illegible]				
Ditto	..	9,321	14·09	338					
Energlyn	1·312	9,960	17·85	428					
Ditto	..	10,464	15·36	368					
Aberbege	..	8,885	17·02	40[illegible]					
Holly Bush	1·269	10,577	12·51						

TABLE. PRACTICAL ANALYSIS OF VARIOUS SCOTTISH CANNEL COALS, BY MR.

Description.	Purified Gas per Ton of Cannel. Cubic Feet.	Specific Gravity of Gas. Air 1000.	Illuminating Power of Gas in Sperm Candles.	Value of One Cubic Foot of Gas in grains of Sperm.	Value of Gas from Ton of Cannel in lbs. of Sperm.	H_2S and CO_2 in Foul Gas. per Cent.	Weight of Coke in lbs. per Ton of Cannel.	Carbon in Coke, per Cent.	Sulphur in Volatile Matters from Ton of Cannel, in lbs.	Sulphur in Coke from Ton of Cannel, in lbs.
Cairntable . . . . . Ayrshire . .	11,480	602	32·83	787·90	1292·20	3·00	1164	94·04	2·68	4·03
Knockshinnock, New Cumnock, ditto . .	10,230	540	25·55	618·20	895·27	5·00	1281	93·80	18·76	6·49
Lanemark ditto ditto . .	10,602	574	29·23	701·50	1062·30	3·50	1241	89·50	22·84	9·41
Muirkirk, No. 1 . . . . ditto . .	12,160	609	32·54	781·20	1356·60	2·91	1125	95·20	7·87	8·55
Ditto, No. 2 . . . . ditto . .	10,658	588	28·34	680·16	1035·60	4·50	1165	89·40	10·58	4·70
Niddry, No. 1, Portobello, Edinburghshire .	11,615	634	30·62	734·88	1219·37	4·25	1037	92·80	15·23	7·17
Ditto, No. 2, ditto ditto . .	11,650	572	27·34	656·16	1092·05	4·50	1139	85·80	15·94	7·13
Inchgall . . . . Fifeshire . .	13,520	656	32·72	785·20	1518·42	3·33	1026	74·20	10·52	5·60
Kirkness . . . . ditto . .	13,825	610	32·13	771·12	1522·96	3·30	1034	75·10	12·11	8·28
Old Wemyss . . . . . ditto . .	13,220	612	32·52	780·48	1482·28	4·30	1036	73·50	16·35	7·61
Allanton, Hamilton . . . Lanarkshire . .	10,561	518	22·32	535·70	808·20	4·75	1272	92·45	19·04	5·37
Benhar, Whitburn . . ditto . .	10,640	581	28·06	673·90	1024·30	5·00	1385	58·20	16·55	9·05
Braehead, Old Monkland . ditto . .	10,033	570	27·06	648·40	930·90	4·30	1267	85·80	16·53	8·33
Bredisholm, Baillieston . ditto . .	10,859	564	27·86	688·60	1037·25	4·50	1245	79·80	13·67	4·92
Chapleside, Airdrie . . ditto . .	13,265	672	35·86	860·60	1630·22	2·25	973	81·11	3·98	2·22
Cleugh, Carnwath . . . ditto . .	11,894	586	28·15	675·60	1150·80	3·00	1193	88·80	10·75	5·82
Crofthead, West Calder . ditto . .	10,535	516	25·32	607·68	914·56	3·35	1234	91·40	5·37	2·91
Dykehead, Airdrie . . . ditto . .	13,126	716	38·71	929·04	1742·08	2·75	1109	84·50	9·40	6·27
Haywood, Carnwath . ditto . .	11,706	586	30·55	733·20	1226·10	3·15	1135	82·80	17·35	5·15
Kirkwood, No. 1, Coatbridge ditto . .	11,615	593	30·04	722·10	1196·20	3·50	1002	87·40	8·06	4·92
Ditto, No. 2, ditto . ditto . .	10,538	578	28·41	681·80	1026·40	2·75	1062	87·20	8·51	3·36
Lesmahago, Main coal . ditto . .	12,420	688	34·26	824·24	1458·88	5·25	1060	86·80	13·66	10·75
Shieldmuir, Motherwell . ditto . .	9,520	536	23·13	555·10	754·96	4·50	1242	91·80	8·56	5·82
Tonnochside, Bellshill . ditto . .	10,913	576	28·32	679·68	1059·62	3·75	1250	82·80	10·30	6·27
Wilsontown, Carnwath . ditto . .	11,120	587	29·04	696·96	1007·17	2·80	1279	92·20	7·84	3·36

NOTE.—The above Table exhibits the results obtained from a few of the principal Cannels out of upwards of 120 kinds from different districts in Scotland. The market value of Cannels is largely affected by the quality of Coke produced. A large proportion of the above number contains only from 80 to 85 per cent. of carbon, which limits their use, and in the manufacture of gas renders an admixture of such Cannels as yield a superior class of Coke for firing purposes indispensable, with the effect of greatly enhancing the price of the latter.

The illuminating power of the gas from the whole of these Cannels was tested with Union burners, No. 8 being used for 30 candles and under; above 30 candles, No. 6 burners, with the rate of consumption gradually reduced below the 5 cubic feet, to prevent smoking, as the scale of quality ascended; the 38-candle gas being tested while burning at the rate of 3·5 cubic feet per hour, and calculated to the 5 cubic feet.

ANALYSIS OF GAS COALS AND CANNELS.

By Mr. James Paterson.

GAS COALS.

Name of Coal.	Situation.	Gas per Ton.	Coke per Ton.	Ash in Coke per Cent.	Specific Gravity of Coal.	Condensation by Bromine.	Illum. Power.	Value of One Cubic Foot in grains of Sperm.	Value of Gas per Ton of Coal in lbs. of Sperm.	Gas purified by One Cwt. Lime.	Sulphur per Cent.
Abram Colliery Co., Wigan 4-feet	Wigan	10,250	1307	5·66	1·270	3·75	15·62	375·	549·	11,000	..
Ditto do. do. 5-feet	Ditto	11,000	1315	7·05	1·276	3·50	14·	336·	532·8	13,000	..
Ditto do. do. 6-feet	Ditto	10,500	1361	6·88	1·235	3·75	15·76	378·	567·36	12,000	..
Ditto do. do. Arley	Ditto	10,500	1463	3·50	1·356	5·10	16·50	396·	594·57	15,000	..
Albert Colliery, Chesterfield gas coal	Newbold, Chesterfield.	10,375	1402	3·33	1·291	4·nearly	14·13	338·	501·	13,000	..
Alliance Coal Co., King coal	Wigan	9,325	1453	5·31	1·289	4·	14·30	343·	471·	..	1·90
Anderton Hall, Arley nuts	Ditto	11,500	1485	2·72	1·280	4·75	18·80	355·	583·	16,000	..
Aston Hall, gas coal	Hawarden, Chester.	8,820	1384	2·38	1·248	5·	16·46	395·	483·	14,000	..
Ditto premier coal	Ditto	11,250	1368	3·37	1·264	4·	16·17	388·	623·43	10,000	..
Atherton Colliery, Arley	Leigh	11,500	1422	3·77	1·287	4·	14·66	350·64	576·	14,000	..
Barley Brook, Arley	Wigan	9,500	1459	4·59	1·274	6·	16·70	401·	544·	..	2·08
Bestwood Coal & Iron Co., gas coal	Nottingham	9,540	1282	6·72	1·242	..	15·14	363·36	495·21	..	..
Bersham Colliery, gas coal	Wrexham	10,600	1336	4·12	1·285	4·	14·50	348·	527·	14,000	..
Bickwell Coal and Coke Co.	Swansea	11,400	1464	6·20	1·274	4·	14·21	341·	555·34	..	0·103
Birley, Silkstone	Barnsley	12,450	1463	1·68	1·266	4·50	16·27	390·48	688·78	15,000	..
Blackleyhurst, Little Delph	St. Helens	9,725	1470	2·75	1·275	4·	13·81	331·	460·	15,000	..
Blainscough Colliery, Arley	Wigan	11,970	1433	3·23	..	4·50	16·39	393·36	672·65	..	..
Bower, P. & R., Woodleford coal	Leeds	12,200	1305	6·30	1·292	4·	16·	384·	614·40	..	1·173
Boythorp, Silkstone	Chesterfield	11,300	1320	3·13	1·242	5·	14·75	354·	571·46	16,000	..
Brinsop Hall, Arley	Wigan	9,980	1444	3·60	1·289	4·50	16·45	394·40	566·30	..	·878
Broughton Coal Co., gas coal	Wrexham, N. Wales	11,800	1340	3·00	1·270	4·	15·07	361·68	609·70	..	..
Brown, John, & Co., Aldwarke main brights	Sheffield	12,600	1428	3·64	1·266	5·25	19·	456·	820·80	..	·300
Brynn Hall, gas nuts	Wigan	11,700	1345	5·33	1·300	3·50	14·13	339·	566·78	..	..

Name of Coal.	Situation.	Gas per Ton.	Coke per Ton.	Ash in Coke per Cent.	Specific Gravity of Coal.	Condensation by Bromine.	Illum. Power.	Value of One Cubic Foot in grains of Sperm.	Value of Gas per Ton of Coal in lbs. of Sperm.	Gas purified by One Cwt. Lime.	Sulphur per Cent.
Brynn Hall, hard coal	Wigan	9,540	1377	5·64	1·260	4·	15·28	367·	500·	..	1·131
Ditto gas coal brights	Ditto	10,800	1324	5·50	1·249	4·50	16·14	387·	597·	14,000	..
Ditto lettered W. C.	Ditto	11,200	1241	5·71	1·242	2·	13·08	313·32	501·31	..	..
Ditto Arley	Ditto	11,250	1428	2·46	1·274	4·25	14·55	349·20	561·21	16,000	..
Chesterfield & Boythorpe, new steam	Chesterfield	10,750	1340	17·00	1·334	4·50	17·11	410·64	630·63	..	3·336
Clifton Hall	Wigan	10,730	1464	3·83	1·289	6·nearly	17·30	414·	636·44	15,000	..
Coop & Co., King coal	Ditto	9,325	1453	5·31	1·289	4·	14·30	343·	471·	..	1·412
Cross, Tetley, & Co., Wigan 4-feet	Ditto	10,000	1336	4·00	1·280	3·75	14·40	425·6	608·	..	·535
Crow Colliery, Ormskirk Park Mine	St. Helens	11,300	1370	3·35	1·287	4·25	16·16	387·84	626·	..	1·360
Coed Talon yard coal	Mold	10,250	1310	7·2	1·344	..	16.96	407·	595·68	..	1·476
Davies, Joseph, gas coal bottoms	Wigan	10,230	1437	3·33	1·282	5·	15·11	362·64	530·	..	..
Ditto do. do. middles	Ditto	10,300	1500	2·61	1·278	5·	15·40	369·60	543·	15,000	..
Ditto do. do. tops	Ditto	11,300	1497	2·41	1·273	5·75	16·81	403·44	651·27	15,000	..
Denaby Main Colliery gas coal screened	Rotherham	12,300	1336	4·	1·283	4·50	16·00	384·	676·17	..	·279
Ditto do. unscreened	Ditto	12,000	1384	5·	1·283	3·75	14·68	352·32	604·	..	·153
Derbyshire Coal Co., gas coal	Ditto	10,775	1465	6·nrly.	1·256	4·full	14·71	353·	543·37	12,000	..
Derbyshire Silkstone	Ditto	11,020	1411	3·21	1·254	..	15·43	370·32	583·	15,000	..
Dewhurst, Hoyle, & Smethurst, Arley	Wigan	10,250	1400	3·33	1·272	5·50	16·33	391·92	576·60	..	·331
Smethurst Hoyle Mine, hard splint	Ditto	10,980	1435	5·67	1·264	4·25	16·78	402·60	620·	15,000	..
Ditto do. Wigan 4-feet	Ditto	10,820	1346	5 79	1·244	4·	16·	384·	593·56	..	·633
Ditto do. gas coal	Ditto	11,050	1420	3·37	1·273	4·	14·14	345·56	545·50	14,000	..
Ditton Coal & Iron Co., Middle Mountain Mine	St. Helens	10,055	1470	1·73	1·222	4·25	17·26	414·	595·	15,000	..
Ebbw Vale Coal & Iron Co., Meadow Vein	Monmouthshire	10,000	1560	7·62	1·304	5·	15·33	367·92	526·60	11,000	..
Ebbw Vale Coal & Iron Co. Rock Vein coal	Ditto	11,350	1495	5·33	1·289	4·50	14·52	348·48	565·	14,000	..
Ebbw Vale Coal & Iron Co. Red Ash coal	Ditto	11,800	1466	3·35	1·274	5·	15·	360·	607·	14,000	..
Evans, R., & Co., Arley	Wigan	12,100	1370	3·	1·241	4·25	16·89	405·36	700·7	..	·811
Fletcher, Burrows, & Co., Arley	Atherton	11,450	1420	2·75	1·260	4·25	16·29	390·69	639·5	..	2·75

Name of Coal.	Situation.	Gas per Ton.	Coke per Ton.	Ash in Coke per Cent.	Specific Gravity of Coal.	Condensation by Bromine.	Illum. Power.	Value of One Cubic Foot in grains of Sperm.	Value of Gas per Ton of Coal in lbs. of Sperm.	Gas purified by One Cwt. Lime.	Sulphur per Cent.
Fodbank, Fifeshire, gas coal	Dunfermline	10,530	1245	5·21	1·295	4·	14·41	366·	550·57	15,000	..
Garswood Coal & Iron Co., Orrell 4-feet	Wigan	11,300	1433	2·50	1·279	4·50	14·91	357·84	577·65	..	..
Garswood Coal & Iron Co., Orrell 5-feet	Ditto	11,350	1368	1·50	1·274	4·50	15·62	375·88	609·46	..	..
Garswood Little Delph	St. Helens	9,000	1419	3·	1·276	4·	14·74	354·	455·17	..	·768
Grosvenor Colliery N. Wales gas coal tops	Wrexham	12,050	1336	4·22	1·260	4·	14·48	347·52	596·26	16,000	..
Grosvenor Colliery N. Wales gas coal bottoms	Ditto	12,225	1307	5·31	1·280	4·65	14·87	357·	609·20	16,000	..
Guy Brothers, Amberwood gas coal	Manchester	9,320	1372	6·66	1.257	4·25	17·15	411·60	548·	13,000	..
Haddock, Little Delph	St. Helens	8,936	1398	3·08	1·274	4·	12·75	306·	391·	15,000	..
Hargreaves, Richard, gas coal	Liverpool	10,270	1470	3·33	1·218	4·	14·72	353·30	518·34	16,000	..
Hazelwood Coal & Cannel Co.	Mold	10,500	1282	5·1	1·260	3·85	14·81	355·44	533·15	..	5·1
Hiebibi Coal Co., Ellerbeck do.	Wigan	12,100	1400	4·32	1·25	5·nearly	15·	360·	622·28	15,000	..
Ditto do. do. best coal	Ditto	11,300	1378	3·11	1·241	4·	14·25	352·	522·	15,000	..
Ditto do. do. Arley 6-feet	Chorley, Wig'n	11,800	1340	3·30	1·244	4·	14·05	337·	598·	..	1·00
Higson, J. & P., Dukinfield Black Mine	Dukinfield	12,100	1495	2·70	1·263	4·70	16·03	384·72	665·	..	·319
Higson, J. & P., Mountain Mine coal	Ashton-u-Lyne	11,250	1550	2·	1·274	4·70	17·31	415·44	667·66	..	·163
Ditto Lille Black Mine	Dukinfield	12,000	1495	2·95	1·274	3.75	15·	360·	617·14	..	·421
Ditto do. Peacock Mine	Ditto	11,100	1488	4·55	1·276	3·25	14·30	343·20	544·21	..	·594
Hindley Field, gas coal	Wigan	10,700	1314	5·45	1·252	4·22	15·26	366·	562·	13,000	..
Ditto do. Wigan 4-feet	Ditto	10,750	1374	7·77	1·248	5·	15·35	368·	565·73	13,000	..
Hindley Green, Arley	Ditto	11,200	1425	2·28	1·268	4·	15·11	366·	585·60	17,000	..
Ditto do. 5-feet	Ditto	9,470	1315	3·21	1·292	4·	13·35	220·4	409·10	14,000	..
Hindley Hall, King coal	Ditto	11,550	1435	2·11	1·131	..	15·36	368·64	608·26	16,000	..
Ditto do. gas coal	Ditto	11,050	1370	4·22	1·282	3·5	13·17	316·	498·83	..	1·00
Ince Hall, Wigan 4-feet	Ditto	10,840	1382	5·17	1·245	5·	16·52	396·48	614·	..	·488
Johnson, Edward, Wigan 4-feet	Ditto	9,950	1336	5·47	1·282	4·	15·44	370·56	526·72	..	·854
Ditto do. Wigan 5-feet	Ditto	11,050	1326	4·11	1·296	4·	13·34	320·16	505·38	14,000	..
Ditto do. Golborne gas coal	Ditto	10,650	1315	3·	1·253	5·6	17·40	417·60	635·35	..	1·253

Name of Coal.	Situation.	Gas per Ton.	Coke per Ton.	Ash in Coke per Cent.	Specific Gravity of Coal.	Condensation by Bromine.	Illum. Power.	Value of One Cubic Foot in grains of Sperm.	Value of Gas per Ton of Coal in lbs. of Sperm.	Gas purified by One Cwt. Lime.	Sulphur per Cent.
Kirkless Yard coal	Ditto	9,780	1464	4·23	1·288	..	15·32	367·70	511·10	..	1·241
Lidgate Colliery	Barnsley	10,500	1368	4·50	1·259	..	16·68	400·32	600·48	..	1·954
Manvers Main, gas coal.	Rotherham	11,000	1366	2·02	1·281	5·	16·62	399·	627·	17,000	..
Milton Colliery	Carlisle	12,400	1400	7·72	1·284	4·	15·26	366·24	648·77	..	·971
Mirfield Coal Co., coal and Cannel mixed	Mirfield	12,600	1430	1·88	1·252	5·15	16·67	400·	720·	17,000	..
Moss Hall, gas coal	Wigan	10,800	1444	2·32	1·266	5·	16·75	402·	620·23	..	1·183
Mountain Mine Coal Co.	St. Helens	11,250	1550	2·	1·274	4·70	17·31	415·44	667·66	..	·163
Neston Colliery Co., gas coal . . .	Cheshire	10,400	1320	4·10	1·261	4·25	16·48	396·	588·34	..	..
Newton, Chambers, & Co.—											
Silkstone	Thorncliffe	13,300	1331	0·79	1·252	4·25	15·14	365·36	694·18	17,500	..
Silkstone nuts	Ditto	13,200	1440	0·88	1·250	4·	14·54	348·96	658·	17,000	..
Silkstone thin seam.	Ditto	12,500	1366	1·32	1·255	4·	14·27	342·48	611·57	15,500	..
Ditto tops and bottoms . . .	Ditto	12,370	1466	1·00	1·262	4·	14·19	340·56	601·82	..	..
Rockingham Silkstone	Ditto	12,500	1432	2·32	1·266	4·nearly	14·45	347·	605·33	16,000	..
Best Silkstone	Ditto	12,180	1441	1·57	1·248	4·75	16·38	393·	683·82	..	..
Screened gas coal	Ditto	12,350	1400	1·30	1·251	4·50	16·	384·	677·49	..	..
Ditto, Parkgate softs	Ditto	11,570	1450	0·93	1·249	4·50	16·50	396·	654·40	..	..
Silkstone softs	Ditto	11,500	1482	0·79	1·247	5·	16·75	402·	660·43	..	..
Newent Coal & Iron Co.	..	11,200	1049	3·45	1·252	..	14·30	343·20	549·12	..	1·153
New Winning, Orrell 4-feet. . . .	Wigan	10,975	1464	4·33	1·266	4·	16·97	407·	638·43	14,000	..
Ditto do. Orrell, 5-feet . . .	Ditto	11 800	1461	5·88	1·268	3·5	13·92	334·	563·	12,000	..
Ditto do. Wigan 4-feet . . .	Ditto	10 150	1400	6·13	1·271	3·5	14·63	351·	509·12	11,000	..
Ditto do. King coal tops . . .	Ditto	10,300	1460	5·22	1·259	3·75	14·53	349·	513·53	12,000	..
Ditto do. King coal bottoms .	Wigan	10,000	1431	5·33	1·262	3·6	14·48	348·	497·	10,500	..
New Zealand, West Coast of Otago .	..	11,525	1400	2·48	1·238	5·	14·95	358·80	590·75	17,000	..
Nunnery Colliery, gas coal . . .	Sheffield	11,100	1430	3·50	1·269	6·	17·70	425·	673·93	16,000	..
Pearson & Knowles, King coal . .	Wigan	10,950	1432	5·27	1·261	4·	14·87	356·89	512·40	..	..
Peasley Cross, Little Delph . . .	St. Helens	9,000	1425	4·75	1·275	..	12·50	300·	386·	..	1·015
Pelsall Coal Co., gas coal	Sheffield	11,530	1320	2·44	1·253	3·60	15·31	367·44	608·65	15,000	..
Pelton Main, Chester-le-St., Durham	Durham	11,600	1560	3·25	1·282	4·75	17·66	424·	702·62	..	1·101
Phœnix Colliery Co., Pigeonhouse coal	St. Helens	11,480	1330	4·37	1·272	4·25	16·18	388·32	636·84	17,000	..

Name of Coal.	Situation.	Gas per Ton.	Coke per Ton.	Ash in Coke per Cent.	Specific Gravity of Coal.	Condensation by Bromine.	Illum. Power.	Value of One Cubic Foot in grains of Sperm.	Value of Gas per Ton of Coal in lbs. of Sperm.	Gas purified by One Cwt. Lime.	Sulphur per Cent.
Plumbley Silkstone	Chesterfield	10,750	1370	6·	1·273	6·	17·42	418·	648·	..	..
Ditto Silkstone nuts	Ditto	10,800	1370	4·20	1·233	5·50	16·93	406·32	627·	..	..
Pope & Pearson, screened Silkstone .	West Riding, Leeds.	12,750	1368	2·44	1·274	4·25	15·26	366·24	667·	16,000	..
Ditto unscreened do. .	Ditto	12,700	1371	3·18	1·278	4·	14·95	358·80	651·	16,000	..
Ditto hard coals . . .	Ditto	10,900	1368	7·31	1·283	4·	15·50	372·	579·26	15,000	..
Roscoe & Lord, Mountain Mine .	Farnworth	11,850	1460	0·64	1·228	5·	15·34	368·16	623·24	18,000	..
Ditto Trencherbone coal .	Ditto	11,150	1462	3·12	1·288	5·50	17·	408·	650·	16,000	..
Ditto One-foot Mine . .	Ditto	11,600	1545	0·61	1·242	5·	14·96	359·	595·	18,000	..
Rose Bridge Colliery, Arley . . .	Wigan	12,600	1493	1·71	1·273	5·	15·40	370·	666·	17,000	..
Ditto do. yard coal . .	Ditto	10,300	1315	2·30	1·271	5·25	15·22	365·30	537·51	..	..
Ditto do. Wigan 4-feet .	Ditto	10,120	1356	6·87	1·265	5·	15·21	365·	527·68	12,000	..
Sankey Brook Coal, St. Helens, 4 ft..	St. Helens	9,230	1368	3·	1·277	5·nearly	16·47	395·28	519·51	..	..
Shakerley Colliery Co.—											
Great seven feet tops	Tyldesley	12,050	1310	4·44	1·276	3·50	13·97	335·30	577·20	14,000	..
Ditto do. bottoms . . .	Ditto	11,800	1305	5·41	1·261	3·50	13·25	318·	536·	14,000	..
Shakerley, Ramsden's gas coal . .	Ditto	10,275	1283	4·51	1·267	6·	17·58	414·72	608·75	..	..
Sheepbridge Coal & Iron Co. . . .	Chesterfield	10,800	1428	5·07	1·277	5·	15·53	372·72	575·	..	0·841
Shirland Colliery, gas coal	Alfreton	11,000	1312	1·85	1·265	4·25	13·46	323·	507·	..	..
Ditto Tipton gas coal .	Ditto	9,800	1402	1·77	1·261	5·	16·22	389·	545·	16,000	..
Silkstone & Dodworth Coal & Iron Co., Old Silkstone	Barnsley	12,240	1498	0·88	1·251	5·	16·66	499·84	699·15	17,000	..
Silkstone & Dodworth Coal, Parkgate coal	Ditto	11,220	1430	1·62	1·271	3·50	15·87	381·	610·70	..	..
Silkstone & Dodworth, Stockton gas coal.	Ditto	12,000	1432	2·11	1·281	5·	16·62	399·	684·	15,000	..
Silkstone & Haigh Moor Coal Co. .	Castleford, Yorkshire.	11,100	1300	4·87	1·271	4·50	17·01	408·24	647·35	..	1·00
Silkstone Fall, gas coal	Barnsley	11,290	1443	This	colliery	has	16·98	407·	656·43	17,000	..
Ditto best Thorncliffe . .	Ditto	11,200	1431	ceased	to	work	17·	408·	652·80	17,000	..
Ditto top bed	Ditto	11,670	1395				15·17	364·	606·84	17,000	..
South Yorkshire Coal Co., Old Silkstone	Ditto	12,300	1456	1·23	1·261	6·30	16·73	401·52	705·53	17,000	..

Name of Coal.	Situation.	Gas per Ton.	Coke per Ton.	Ash in Coke per Cent.	Specific Gravity of Coal.	Condensation by Bromine.	Illum. Power.	Value of One Cubic Foot in grains of Sperm.	Value of Gas per Ton of Coal in lbs. of Sperm.	Gas purified by One Cwt. Lime.	Sulphur per Cent.
Spring Colliery, yard coal	Wigan	10,450	1456	3·62	1·291	5·	18·81	319·	476·22	16,000	..
Ditto Smith coal	Ditto	9,800	1463	2·11	1·208	5·80	15·22	365·	511·39	16,000	..
St. Helens Colliery, Rushy Park	St. Helens	11,100	1370	2·50	1·276	4·	14·37	340·	539·14	15,000	..
Ditto Little Delph	Ditto	11,100	1370	2·37	1·269	4·	14·89	345·36	547·66	15,000	..
Staveley, gas coal, tops	..	9,040	1395	4·32	..	..	11·52	270·	350·	18,000	..
Ditto do. bottoms	..	10,100	1340	4·50	1·280	..	12·23	294·	424·	13,000	..
Swan Lane Colliery, gas coal	Wigan	9,400	1314	2·42	1·242	4·73	16·82	404·	542·50	18,000	..
Syndall Hall, Arley	Barnsley	10,150	1291	3·22	1·291	6·	17·80	434·	630·	15,000	..
Tawd Vale Colliery Co., gas coal	Ormskirk	10,420	1360	4·22	1·276	4·80	15·64	375·36	558·75	13,000	..
Ditto do. Rushy Park	Ditto	11,200	1400	3·24	1·259	4·15	14·50	348·	556·80	16,000	..
Ditto do. New Arley	Ditto	10,800	1431	2·78	1·272	5·75	16·96	390·80	575·	16,000	..
Tyldesley Coal Co., Crombouke	Wigan	9,800	1320	2·63	1·231	5·	15·64	375·36	525·50	..	..
Ditto do. gas coal	Ditto	10,600	1320	2·50	1·269	5·15	16·	384·	581·50	14,000	..
Unston Colliery Co., coal	Sheffield	10,375	1400	2·00	1·274	..	13·57	325·70	482·73	..	..
Victoria Colliery, Rushey Park	Rainford	10,030	1264	2·88	1·260	4·52	13·63	327·	454·	15,000	..
Vauxhall Colliery	Wrexham	12,300	1463	3·41	1·263	4·50	14·39	345·36	606·82	15,000	..
Wells, Birch, Ryde, & Co., hard coal	Barnsley	11,600	1447	2·50	1·263	6·25	18·20	436·80	723·70	17,000	..
Ditto do. soft coal	Ditto	10,450	1525	13·50	1·270	4·50	16·88	405·12	604·78	..	..
Ditto do. old Silkstone	Ditto	11,500	1463	1·50	1·263	6·50	18·50	444·	729·42	..	..
West Lancashire Coll. Co., gas coal	..	9,700	1338	4·11	1·271	..	14·54	347·	480·84	14,000	..
Wharncliffe, Silkstone	Barnsley	12,600	1418	0·95	1·247	4·75	16·21	389·	700·	16,000	..
Ditto Parkgate coal	Ditto	12,750	1460	7·00	1·279	4·50	16·95	406·80	740·96	..	·658
Ditto, Silkstone Coll. Co., Flockton coal	Ditto	11,550	1431	6·65	1·283	..	17·16	411·84	679·53	..	·798
Ditto do. Waids upper seam coal	Ditto	11,200	1463	7·00	1·276	..	18·18	436·32	698·11	..	1·088
White Moss Co., Park Mine coal	Ormskirk	11,400	1423	2·31	1·275	4·75	15·37	366·88	586·45	..	..
Wigan and Whiston, gas coal	Wigan	9,750	1412	2·94	1·280	3·50	13·75	330·	459·64	..	..
Ditto do. Rushy Park	Prescot	10,300	1441	1·87	1·275	5·25	15·	360·	529·71	16,000	..
Wigan Coal & Iron Co., Arley	Wigan	11,840	1449	1·79	1·275	5·25	15·37	367·	620·75	..	..
Ditto do. Lady Lane, Arley	Ditto	12,000	1428	2·02	1·246	5·75	16·10	386·40	662·40	17,000	..
Ditto do. Gidlow, Arley	Ditto	11,200	1495	5·20	1·290	4·50	16·4	393·60	631·20	..	..
Ditto do. Hindley, Arley	Ditto	11,800	1430	2·00	1·245	5·50	16·84	404·2	681·36	..	·320

CANNELS.

Name of Cannel.	Situation.	Gas per Ton.	Coke per Ton.	Ash in Coke per Cent.	Specific Gravity of Coal.	Conden-sation by Bromine.	Illum. Power.	Va'ne of One Cubic Foot in grains of Sperm.	Va'ne of Gas per Ton of Coal in lbs. of Sperm.	Gas puri-fied by One Cwt. Lime.	Sul-phur per Cent.
Abram Coal Co., Wigan 4-feet cannel	Wigan	14,800	1024	5·08	1·134	20·25	29·23	701·52	1483·21	17,000	..
Alliance Coal Co., Wigan cannel . .	Ditto	12,830	1370	4·88	1·264	9·52	20·71	497·	911·	13,000	..
Ditto do. Stone cannel . .	Ditto	10,500	1241	9·21	1·312	6·50	18·24	437·76	656·64	8,000	..
Bersham Coal Co., Bersham cannel .	Wrexham	12,450	1180	3·33	..	6·25	15·35	368·40	965·23	..	..
Bestwood Coal Co., Bestwood cannel	Nottingham	11,680	1209	19·83	1·237	6·75	18·21	437·	729·17	..	..
Blundell & Son, Wigan cannel . .	Wigan	11,870	1415	4·37	1·262	11·5	22·78	546·72	927·08	14,000	..
Ditto do. Pemberton cannel .	Ditto	12,400	1305	4·80	1·277	11·75	21·80	523·20	927·	..	·727
Boghead, black variety	Bathgate	15,750	817	68·21	1·175	22·25	38·39	912·36	2073·	..	..
Bowers, Allerton cannel	Leeds	11,400	1300	8·21	1·281	8·25	20·43	490·32	798·52	14,000	..
Bower, T & R., Woodleford cannel .	Ditto	11,500	1209	7·	1·288	..	19·	456·	749·14	..	1·288
Brancker & Co., Wigan cannel . .	Wigan	12,770	1402	4·48	1·262	10·	22·20	533·	972·34	..	..
Broadway Colliery, Broadway cannel	Mold	10,785	1288	5·33	1·272	7·75	16·52	396·50	611·	..	..
Bromilow, D., & Co., St. Helens . .	..	11,100	1340	5·60	1·273	9·60	21·64	519·36	823·56	..	·441
Bromley, U., Leeswood curley . .	Mold	15,875	913	29·73	1·138	16·45	28·66	687·8	1559·83	..	·634
Ditto do. do. smooth . .	Ditto	11,570	1200	7·68	1·276	8·25	19·87	477·	788·41	..	1·034
Brown, John, & Co., band of cannel in coal.	Sheffield	9,275	1460	35·7	1·41	..	22·14	531·36	704·	..	..
Coed Talon, smooth cannel . . .	Mold	10,800	1344	69·	1·288	9·33	22·67	543·	838·	..	·735
Ditto curley cannel. . . .	Ditto	13,600	903	68·70	1·228	16·37	27·75	666·	1294·	..	·680
Crippin, W. & F., 4-feet cannel W.R.	Wigan	17,300	920	7·77	1·122	12·75	30·07	721·68	1783·56	16,000	..
Ditto do. do. T. B.	Ditto	13,460	922	6·13	1·165	10·77	23·58	564·72	1328·	..	..
Ditto do. do. T. B.	Ditto	14,100	1047	6·75	1·176	9·25	19·47	467·30	941·27	14,000	..
Ditto do. do.	Ditto	12,200	1360	3·63	1·274	4·	14·31	343·44	598·57	..	..
Cross, Tetley, & Co., Wigan 4-feet cannel	Ditto	14,200	1025	9·50	1·217	20·30	29·40	705·60	1431·36	..	·488
Ebbw Vale Coal & Iron Co.	Monmouthshr.	11,270	1463	6·32	1·328	8·	19·57	469·68	756·12	15,000	..
Edge Green Coal Co., Edge Green cannel	Wigan	10,540	1348	7·83	1·244	10·20	19·63	470·	708·	..	1·011

Name of Cannel.	Situation.	Gas per Ton.	Coke per Ton.	Ash in Coke per Cent.	Specific Gravity of Coal.	Condensation by Bromine.	Illum. Power.	Va'ue of One Cubic Foot in grains of Sperm.	Va'ue of Gas per Ton of Coa' in bs. of Sperm.	Gas purified by One Cwt. Lime.	Sulphur per Cent.
Ellis Lever & Co., Shirland cannel .	..	11,600	1241	3·65	1·288	7·50	19·36	464·64	769·97	..	1·210
Fiddler, Edward, Coppa smooth . .	Mold	11,700	1180	6·50	1·272	7·50	19·02	471·	787·24	..	..
Ditto do. curley . .	Ditto	16,000	900	33·	1·145	16·	27·55	616·20	1511·31	..	..
Firtree Colliery, 4-feet cannel . .	Wigan	11,900	1210	13·70	1·213	..	15·75	378·	643·	9000	..
Fletcher, Burrows, & Co., Arley cannel	Atherton	12,500	1305	4·80	1·287	6·25	20·11	482·64	719·	..	·224
Garswood Hall, cannel	Wigan	12,750	1000	9·37	..	9·25	27·13	651·	1185·7	..	..
Ditto do. semi-cannel . .	Ditto	10,700	1360	4·	1·276	5·50	16·82	408·68	617·	13,000	..
Garswood Coal & Iron Co., C. F. Clark, Esq.	Park Lane, do.	10,620	1370	6·87	1·292	7·00	22·00	528·	831·05	..	..
Ditto do. do. . . .	Ditto	9,975	1440	23·65	1·397	6·25	18·77	450·50	641·96	..	..
Guy Brothers, cannel nuts	Manchester	11,175	1337	16·50	1·277	6·25	20·67	496·08	800·	..	·772
Haigh, John, & Sons, No. 1. . . .	Gildersome, Sheffield.	11,500	1340	6·25	1·272	6·21	17·27	416·40	743·57	16,000	..
Ditto do. No. 2. . . .	Ditto	10,800	1348	6·30	1·271	5·30	16·57	397·70	618·	16,000	..
Hazelwood Coal Co., Mold Coed Talon cannel	Mold	14,200	927	3·45	1·174	13·00	27·38	657·12	1332·44	..	·540
Hiebibi Collieries, Ellerbeck cannel.	Wigan	11,650	1340	5·25	1·268	9·25	19·43	466·32	776·09	14,000	..
Hindley Field, Wigan 4-feet cannel .	Ditto	12,800	1053	7·40	1·084	13·75	23·25	558·	1027·	14,000	..
Higson, J. & P., Dukinfield do. . .	Dukinfield	11,850	1276	7·	1·274	9·50	24·	576·	973·66	..	·354
Ince Hall, Wigan cannel	Wigan	12,780	1411	4·44	1·262	9·75	22·35	530·	979·	14,000	..
Lawton Colliery, Lawton cannel . .	Stoke-on-Trent	8,000	nil.	..	1·317	8·65	22·	583·	609·	..	..
Little Heaton cannel	St. Helens	13,300	1413	4·88	1·273	6·75	16·50	396·	752·40	14,000	..
Lockwood, T., Howley Park . . .	Batley	11,400	1310	8·65	1·273	14·	26·	624·	1016·23	..	..
Mostyn cannel.	Flint	10,650	1413	4·88	1·273	6·75	16·50	396·	1752·40	14,000	..
Moss Hall, Wigan 4-feet cannel . .	Wigan	10,600	1300	12·95	1·284	9·nearly	22·88	549·	831·34	..	·542

Name of Cannel.	Situation.	Gas per Ton.	Coke per Ton.	Ash in Coke per Cent.	Specific Gravity of Coal.	Condensation by Bromine.	Illum. Power.	Value of One Cubic Foot in grains of Sperm.	Value of Gas per Ton of Coal in lbs. of Sperm.	Gas purified by One Cwt. Lime.	Sulphur per Cent.
New South Wales cannel	..	15,300	818	71·	1·134	22·25	38·43	922·32	2126·	..	..
Nichols, J. H., Old Hall cannel	St. Helens	11,200	1250	5·20	1·318	8·2	23·	552·	883·20	..	1·103
Nunnery Colliery, cannel	Sheffield	12,750	1336	10·	1·31	5·15	18·14	435·36	793·	..	2·320
Ormiston, J., Flint cannel	Flint	13,000	1245	12·8	1·35	9·75	21·79	527·30	979·27	..	·371
Pearson & Knowles, Wigan cannel	Wigan	11,870	1415	4·37	1·262	11·5	22·78	546·72	927·08	14,000	..
Radley, J., Sutton Heath New Pit	St. Helens	12,700	1249	4·50	1·234	..	22·45	538·80	977·54	..	·878
Rose Bridge, Wigan cannel	Wigan	11,125	1414	5·	1·268	11·75	22·63	543·	863·	..	..
Roscoe & Lord, Mountain Mine cannel	Farnworth	11,850	1416	0·65	1·284	5·75	16·	384·	605·	18,000	..
Royal Colliery, Wigan cannel	St. Helens	11,675	1388	5·22	1·271	·925	20·56	493·44	823·	..	..
Sankey Brook Colliery, cannel, in band of coal	Ditto	10,300	1180	7·50	1·255	9·5	22·00	528·	777·	..	..
Scott Lane Colliery, Wigan cannel	Wigan	11,980	1411	4·60	1·260	11·38	22·80	547·	936·	..	..
Sheepbridge Coal & Iron Co.	Chesterfield	9,750	1370	17·45	1·340	..	21·30	511·20	712·	..	·386
Shirland Coal Co., Shirland cannel	Alfreton	10,600	1300	2·95	1·284	9·	22·88	549·	831·34	..	..
Silkstone and Haigh Moor cannel	Allerton, Castleford.	12,325	1209	6·12	1·250	12·00	21·83	509·52	897·12	..	·912
Simpson & Co., Wigan 4-feet cannel.	Wigan	12,600	1088	5·45	1·172	9·50	22·80	549·	964·29	..	..
Smethurst, D. H. & Co., 3-feet seam, tops	Ditto	11,600	1306	4·50	1·286	8·	21·	504·	835·20	..	..
Smethurst, D. H., & Co., 3-feet seam, bottoms	Ditto	11,425	1337	5·	1·290	8·	20·53	492·72	797·33	..	..
Sutton Heath, cannel	St. Helens	12,900	1411	5·42	1·266	8·75	19·15	459·60	847·	..	..
Thomson, S., Ibstock cannel	Motherwell	11,500	1112	15·	1·266	9·50	18·01	432·24	710·11	..	1·246
Wigan Coal & Iron Company—											
Wigan cannel.	Wigan	11,580	1400	4·32	1·264	9·50	22·73	546·	889·	14,000	..
Curley cannel.	Ditto	12,600	1241	8·	1 279	13·00	27·50	660·	1188·	..	..
Smooth cannel	Ditto	12,100	1388	2·50	1 275	16·35	24·17	580·	1002·57	..	..
Worsley Cannel	Worsley, near Manchester.	11,030	1439	7·32	1·290	9·13	19·	456·	719·	..	1·134

CANNEL AND COAL NUTS AND SLACK OR DROSS

Are only suitable for making gas where high heats are kept up. They cannot be used to advantage in Iron Retorts. When the heat is not high they cake together in a mass, and at the end of the charge are drawn from the retort in a comparatively unspent condition.

TABLE

Showing, by the Chlorine and Durability Test, the Comparative Value of Various Coals. (Dr. Fyfe.)

Coals.	Cubic Feet of Gas per Ton.	Condensation by Chlorine in 100 parts.	Durability, with Jet Flame, 5 inches, 1 ft. burns. min.	sec.	Value of Gas according to Condensation by Chlorine and to Durability.	Value of Coals according to Value and Quantity of Gas.
English caking	9,746	6·5	50	40	1·00	1·00
English parrot, average	10,500	7·6	44	30	1·02	1·08
Marquis of Lothian's	10,000	13·0	60	0	2·35	2·41
Lesmahago	10,176	17·5	70	0	3·72	3·87
Wemyss	10,000	19·5	75	0	4·44	4·55
Kirkness	9,620	20·75	80	18	5·06	4·99
Boghead	15,486	28·37	84	22	6·09	9·67

TABLE

Giving the Result of the Distillation for Gas and for Oil, of One Ton of Newcastle Cannel Coal. (Gesner.)

Distilled for Gas, at 1000° *to* 1200° *Fahr.*		*Distilled for Oil, at* 750° *to* 800° *Fahr.*	
PRODUCTS.		PRODUCTS.	
Coal gas	7450 cub. ft.	Gas	1400 cub. ft.
Coal tar	18½ gals.	Crude oil	68 gals.
Coke	1200 lbs.	Coke	1280 lbs.
PRODUCTS OF THE COAL TAR.		PRODUCTS OF THE CRUDE OIL.	
Benzole	3 pints.	Eupion	2 gals.
Coal tar naphtha	3 gals.	Lamp oil	22·5 gals.
Heavy oil, naphthaline, &c.	9 gals.	Heavy oil and paraffin	24 gals.
Total	12⅜ gals.	Total	48·5 gals.

WIGAN CANNEL AND COAL

Produce, on an average, per ton :—

	Cannel.	Coal.
Gas	10,900 cubic feet	9980 cubic feet.
Illuminating power	24 sperm candles	14 sperm candles.
Coke	1436 lbs.	1517 lbs.
Tar	17 gallons	11 gallons.
Ammoniacal liquor	18 gallons	20 gallons.

NEWCASTLE COAL

Produces, on an average, per ton :—

Gas	9700 cubic feet.
Illuminating power	15 sperm candles
Coke	1540 lbs.
Tar	9 gallons.
Ammoniacal liquor	10 gallons.

TO DETERMINE THE SPECIFIC GRAVITY OF COAL.

Take a small piece of the coal, suspend it by means of a horsehair from the under side of the pan of a carefully adjusted balance, and weigh it both in and out of water (fresh distilled); divide its weight in the air *by the loss of weight* in the water, and the quotient is the specific gravity.

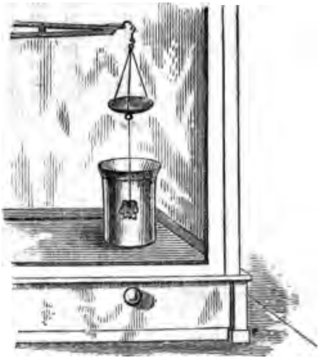


FIG. 1.

EXAMPLE.

A piece of coal weighs, say	480 grains.
Loss of weight when weighed in water	398 „

Then $\frac{480}{398} = 1{\cdot}206$ specific gravity of the coal compared with water as 1·000.

Note.—Specific gravity is the relative weight of equal bulks of *different substances*, distilled water at 62° Fahr. being taken as the standard of comparison. At this temperature a cubic foot of water weighs 1000 ounces avoirdupois. *Hence the specific gravity of a body is also its weight in ounces avoirdupois per cubic foot;* so that, knowing the specific gravity, the weight of any quantity of matter may be calculated by simple measurement. For example: In the instance given above, the specific gravity is shown to be 1·206; the weight of the coal per cubic foot is, therefore, 1206 ounces, or 75·4 lbs. avoirdupois.

TO FIND THE VALUE OF GAS IN GRAINS OF SPERM PER CUBIC FOOT, FROM THE GIVEN ILLUMINATING POWER.

Rule.—Multiply 120 (the grains allowed per hour for the consumption of the standard sperm candle) by the illuminating power, and divide by 5 (consumption of gas in cubic feet per hour by the standard burner). The answer will be the value of the gas in grains of sperm per cubic foot.

Example.—What is the value of gas in grains of sperm per cubic foot, the illuminating power of which is 19·46 candles?

$$\frac{19{\cdot}46 \times 120}{5} = 467 \text{ grains of sperm.—}\textit{Answer.}$$

TO FIND THE VALUE OF ANY COAL PER TON IN POUNDS OF SPERM, THE YIELD OF GAS AND ILLUMINATING POWER BEING KNOWN.

Rule 1.—Multiply the cubic feet produced per ton by the value of the gas in grains of sperm per cubic foot (ascertained by the previous rule), and divide by 7000 (the number of grains in 1 lb. avoirdupois). The answer will be the value of the coal in lbs. of sperm per ton.

Example.—What is the value of a certain coal in lbs. of sperm per ton, whose yield of gas is 10,540 cubic feet, and illuminating power 19·63 standard sperm candles?

$$\frac{19{\cdot}63 \times 120}{5} = 471{\cdot}12, \text{ value of the gas in grains of sperm per cubic ft.}$$

Then $\frac{10{,}540 \times 471{\cdot}12}{7000} = 709{\cdot}37$ lbs. of sperm per ton, value. Or by

Rule 2.—Divide the yield per ton by 5 (cubic feet of gas consumed per hour by standard burner), multiply by the ascertained illuminating power and by 120 (consumption of standard sperm candle per hour in grains): lastly, divide by 7000 (number of grains in 1 lb. avoirdupois). The answer will be the value of the coal in lbs. of sperm per ton.

Example.—What is the value of a certain coal in lbs. of sperm per ton, whose yield of gas is 10,540 cubic feet, and illuminating power 19·63 standard sperm candles? Then

$$\frac{10{,}540}{5} = \frac{2108 \times 19{\cdot}63 \times 120}{7000} = 709{\cdot}37 \text{ lbs. of sperm per ton, value.}$$

TO ASCERTAIN THE RELATIVE VALUE OF DIFFERENT COALS AND CANNELS.

To ascertain the relative value per ton of different coals and cannels, attach approximate or actual market prices to the sperm lbs. as ascertained above, and to the several residual products; cast up the various items and compare them by the ordinary rule of proportion.

Example.—The two coals to be compared are—

No. 1, yielding—		£	s.	d.
10,600 c. ft. of gas per ton, 17½ candles value, = 636 lbs. sperm	at 1s.	31	16	0
13½ cwt. Coke	at 5d.	0	5	7½
10 gals. Tar	at 1¼d.	0	1	0½
22 gals. Ammoniacal Liquor . . .	at 1d.	0	1	10
		£32	4	6

No. 2, yielding—		£	s.	d.
9,700 c. ft. of gas per ton, 16¾ candles value, = 557 lbs. sperm	at 1s.	27	17	0
14 cwt. Coke	at 5d.	0	5	10
9 gals. Tar	at 1¼d.	0	0	11¼
20 gals. Ammoniacal Liquor . . .	at 1d.	0	1	8
		£28	5	5¼

Assuming that No. 1 is 12s. 6d. per ton, the relative value of No. 2 will be found as follows:—

As £32 4s. 6d : £28 5s. 5¼d. : : 12s. 6d. : 10s. 11½d. value per ton of No. 2.

TO FIND THE RELATION BETWEEN QUANTITY OF GAS PER TON AND ILLUMINATING POWER. (Farmer.)

If a coal yields a known volume of gas of a known illuminating value, to ascertain how much it will yield of another value:

Rule.—Multiply yield of gas by illuminating power, divide by the *required* power, and the quotient is the quantity.

Example.—A coal yields 9600 cubic feet per ton of 16-candle gas; how much will it yield of 14 and 17 candle gas respectively?

$$9600 \times 16 = 153{,}600. \text{ Then}$$

$$\frac{153{,}600}{14} = 10{,}971 \text{ c. ft. and } \frac{153{,}600}{17} = 9035 \text{ c. ft.}$$

The above presupposes that the period of distillation is extended or abridged, as the case may be. The rule, however, must not be assumed as absolutely correct, but only approximately so, and that only within a limited range.

WEIGHT OF COAL.

Anthracite, per cubic yard, solid	2160 lbs.
Bituminous ,, ,, ...	2025 ,,
Cannel ,, ,, ...	2160 ,,
Coal, stored in the usual way, per cubic yard . . .	1400 ,,

COAL STORAGE.

In storing coal, 43 cubic feet of space per ton is required.

ANNUAL CONSUMPTION OF COAL FOR GAS PURPOSES IN THE UNITED KINGDOM.

It is estimated that the present (1883) annual consumption of coal for the manufacture of illuminating gas in the United Kingdom is about 10,000,000 tons; about 2,000,000 tons (or 20 per cent.) of this quantity being cannel coal.

AVERAGE YIELD OF BITUMINOUS COAL.

The average percentage yield, by weight, of good bituminous coal, is as follows:—

	Per Cent.
Gas	16
Coke and Breeze	68
Tar	4¾
Ammoniacal Liquor	7½
Residue, Ash, &c.	3¾
	100

FOR ROUGHLY ESTIMATING THE AMOUNT OF COAL OR CANNEL REQUIRED TO PRODUCE A GIVEN QUANTITY OF GAS.

Rule.—Strike off the last four figures from the quantity of gas produced, and the figures remaining will represent the coal and cannel in tons.

Thus: 20|0,000 cubic feet = 20 tons.

This will be evident when it is remembered that a ton of coal or cannel produces about 10,000 cubic feet of gas. If the production rise to 11,000, or fall to 9000 per ton, one-tenth must be deducted from, or added to, the coal, as the case may be.

COAL AND CANNEL SHEDS.

In gas making it is economical to use the coal as fresh as possible from the pit, but, to be prepared for emergencies, the covered storage room for coal and cannel should be of capacity sufficient to contain from six to eight weeks' stock of the material, reckoned on the basis of the heaviest day's consumption in winter. An exception to this rule may be made in the case of gas-works situated in the immediate vicinity of the coal fields from whence the supply is derived. Under such circumstances, provision for two or three weeks' stock is ample.

All kinds of coal suffer deterioration by exposure to the weather, both as regards their heating, coking, and gas-yielding qualities. The extent of this deterioration is from 20 to 50 per cent. within a period of a few months. An absolute loss of weight, due to the evaporation or slow combustion of the more volatile constituents, is also experienced. This is particularly the case with bituminous or caking coal; cannel suffers next in degree, and anthracite the least. Varrentrapp found in one instance that coal which had been exposed for some years to the weather had diminished in weight to the extent of 38·03 per cent.

Wet or damp coal not only yields less gas, but gas of an inferior quality. The sulphur impurities given off from it are more, thus augmenting the cost of purification; whilst some of the sulphur compounds—notably, bisulphide of carbon—are not removable, except by a greatly increased area of purification, beyond what is to be found at most gas-works.

SPONTANEOUS IGNITION OF COAL.

Coal containing a large proportion of iron pyrites (bisulphide of iron), commonly called "brasses," when stored in a compact mass in a wet or humid state, is liable to spontaneous ignition. Notwithstanding a conflict of opinion on the point, we believe that the best remedy for this is ventilation. Various expedients are resorted to for effecting this object, amongst which may be mentioned the insertion of perforated iron pipes amongst the coal, leaving the ends exposed; coarse wicker-work baskets, without bottoms, are used with good results; and ventilating shafts of brick, or venetianed shafts of wood, both horizontal and vertical, have proved efficient. A thermometer let down through the pipes or shafts will indicate any rise of temperature, and iron rods thrust into the mass of coal, when withdrawn and touched by the hand, will answer the like purpose.

When the pyrites are present to a serious extent, the coal should be hand-picked, either at the colliery or when discharging at the gas-works. It is only sheer necessity, however, that will justify the employment of coal of this character for gas-producing purposes.

THE GASES OCCLUDED IN COAL.

Besides the liability to spontaneous combustion or ignition, there is another strong reason why coal should not be stored for a longer time than is absolutely necessary. In all bituminous coals a constant chemical change is in progress by which gas is being liberated. This, though frequently several times the volume of the coal, is condensed within the solid substance, being occluded or enclosed therein, until by diffusion it escapes into the air, and to such extent the coal is depreciated for gas making. In warm weather and in hot climates this deterioration proceeds more rapidly than in low temperatures.

Dr. Lyon Playfair and others in this country, and Dr. E. Von Meyer in Germany, have investigated the subject, and the subjoined table by the latter shows the quantity and composition of the gas so occluded, *obtained from* freshly raised samples of coal submitted to him for *analysis.*

The plan adopted was to place 100 grammes of the coal in hot de-aërated water, which was then boiled as long as any gas continued to be given off, and the gas collected was analyzed by Bunsen's methods.

	Samples of Coal Submitted.	Fathoms from Surface.
No. 1.	Low Main Seam, Bewick Colliery, Newcastle	—
2.	Maudlin Seam, ditto ditto	—
3.	Main Coal Seam, Urpeth Colliery, ditto	—
4.	Five-fourth Seam, ditto ditto	30
5.	Ditto Wingate Grange Colliery, Durham. .	74
6.	Low Main Seam, ditto ditto . .	108
7.	Harvey Seam, ditto ditto . .	148
8.	Ditto Emily Vil, Woodhouse Close Colliery.	25

ANALYSIS.

PERCENTAGE COMPOSITION OF THE GAS.

Coal as above.	CO_2	CH_4 Marsh Gas.	O	N	Cubic Centimètres of Gas from 100 Grammes of Coal.
No. 1. . . .	5·55	6·52	2·28	85·65	25·2
2. . . .	8·54	26·54	2·95	61·97	30·7
3. . . .	20·86	. .	4·83	74·31	27·4
4. . . .	16·51	Trace.	5·65	77·84	24·4
5. . . .	0·84	85·80	Trace.	13·36	91·2
6. . . .	1·15	84·04	0·19	14·62	288·0
7. . . .	0·23	89·61	0·55	9·61	211·2
8. . . .	5·31	50·01	0·63	44·05	84·0

1 cubic centimètre = 610·23 cubic inches.
1 gramme = 0·0022lb. avoirdupois, 100 = ·22 lb.

RETORT HOUSE.

Dimensions.

For a single bench of retorts—
  Width inside, 30 feet.
  Height to wall plate, 20 feet.
For a double bench of retorts—
  Width inside, 60 feet.
  Height to wall plate, 26 feet.

Wrought-iron trussed roof, slated, tiled, or covered with corrugated galvanized iron sheets, with ventilator.

The ventilator should extend from one end of the building to the other, and be of ample capacity. Suitable openings should be eft in the walls, above the height of the retort-bench, for the admission of air and light. Ventilating tubes or towers may be used alone or in conection with the louvre ventilator. They are efficient, and present a good appearance.

Corrugated-iron sheeting, being lighter than slates or tiles, admits of the principals' being placed wider apart, so reducing their number. The first cost of a roof of this description is less; it is less affected by wind, but its durability is inferior to a slated roof. The sheets should not be thinner than No. 18 gauge.

The clear space in front of a retort-bench should not be less than 20 feet. When it is intended to employ machinery for charging and drawing, 22 feet should be allowed.

About 8 feet of the width of the floor, immediately in front of the bench, may be paved with fire-bricks set on edge; the remainder of the floor flagged with 4-inch flags. Blue Staffordshire bricks or tiles, 4 inches thick, make an excellent paving for a retort-house floor, and when these are used, the fire-bricks in front of the bench may be dispensed with.

A slight inclination, say 6 inches in the whole width, towards the bench should be given to the floor. This allows the waste water from the slaked coke to run into the ash-pans, and is also handier for the stokers in charging.

A stage floor retort-house costs in erection from 50 to 75 per cent. more than a ground floor house (dependent on the character of the site and subsoil); but it can be worked with more economy, and the advantages it offers for the removal of the coke, the application of generator furnaces, and in other ways, are very great. In all cases where the site naturally favours this form of construction, it should be adopted. The stage floor is usually formed of cast-iron plates, laid on girders having their ends built into the wall of the house and the division piers of the bench, and supported at the centre by cast-iron columns.

THE RETORT STACK.

This necessarily varies in size and mode of construction, according to the number of retorts, their dimensions, and arrangement in the setting. The following details will be found adequate for the erection of a stack with benches of seven large retorts of any shape, and either single or throughs, set as shown in Fig. 2.

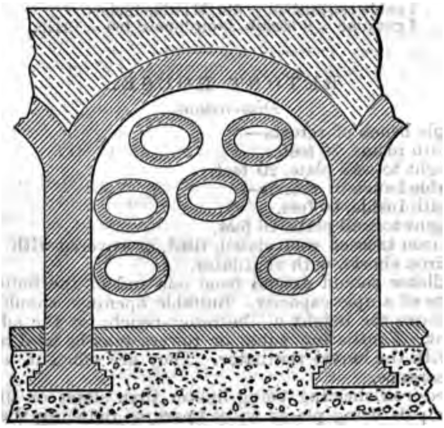


FIG. 2.

The ovens are 8 ft. 6 in. wide, 8 feet high from floor line, and 20 feet through, inside measure.

Height to top of bench, 10 ft. 3 in.

Excavation for bench, 3 feet deep.

Place therein bed of hydraulic lime concrete, 14 inches thick.

Upon this build the brick footings of the division walls of ovens, of good hard common bricks, set in lime mortar.

When these are built, fill up between with a further layer of concrete, 13 inches thick.

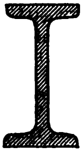


FIG. 3.

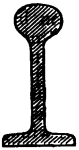


FIG. 4.

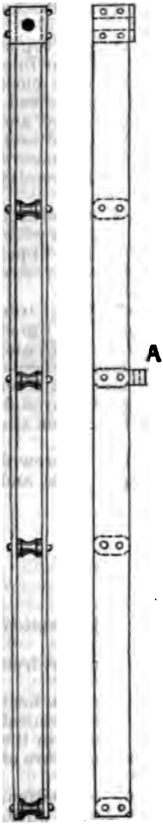


FIG. 5.

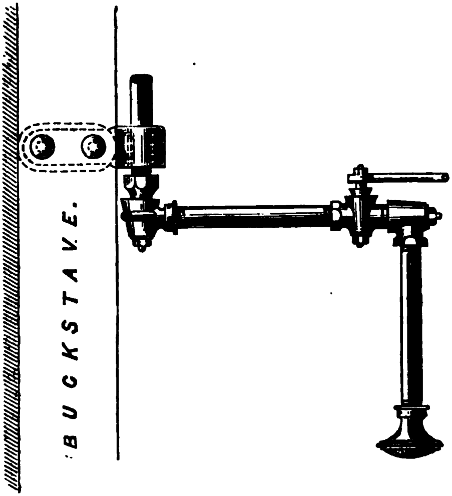


FIG. 6.

Division walls of ovens above footings, 18 inches thick, built of best fire-clay bricks, set in fine, well-tempered fire-clay.

Floor of ovens paved two courses on edge with fire-bricks set in fire-clay.

Arched roof of ovens, 14 inches thick, formed of three rings of fire-bricks moulded to the proper radius set in fire-clay.

Two flue-holes in crown of arch, 12 inches square, communicating with main flue on stack. Damper tiles to be provided for these, 27 inches long, 16 inches wide, 3 inches thick.

End or buttress walls of stack, 3 ft. 4½ in. thick, of common bricks, built in with the fire-brick work of stack, and faced with fire-bricks, laid in good lime mortar.

The whole of top of stack haunched up five courses above the top of the arches, so as to make the total height of 10 ft. 3 in. from floor line, of good common bricks faced with fire bricks, laid solid, with close joints, in good lime mortar. Finish with cornice or coping as desired.

Double main flue on the stack, built of fire bricks, set in fire-clay, and continue to the opening provided in the chimney. Dimensions of each flue, not less than 30 inches deep, 15 inches wide, inside measure. Outside walls and division wall, 9 inches thick, covered with fire-clay tiles 2 ft. 4½ in. wide, 4 in. thick, rebated at joints.

Buckstaves of wrought-iron, either rolled girder (Fig. 3) or rail-iron (Fig. 4), or, what is still better, formed of two flat-iron bars 6 inches wide, and 1 inch thick, with five cast-iron distance pieces between (the upper one being square in form), through which the plates are rivetted together with ¾ in. rivets (Fig 5).

The boss, A, with hole therein is intended to receive the wrought-iron pipe, 1-inch diameter, leading from the 3-inch water main on the top of the retort stack. To the end of this pipe a brass swivel is attached, and from this again a piece of 1-inch steam tubing, 11 inches long, projects, having a brass swivel cock at its end; a tube ¾ of an inch diameter is screwed thereto, and terminates in a 4-inch brass rose jet, through which water is discharged for slaking the coke as it is drawn from the retorts (Fig. 6).

Tie rods of 1½ inches square bar, or 2 inches round-iron; screwed 6 inches at each end, and furnished with strong hexagon nuts and washers.

RETORTS.

Materials of which Retorts are made.

The materials of which retorts for the distillation or carbonization of coal are made, are fire-clay and iron exclusively.

In the early days of gas lighting, and for many years after, cast-iron retorts only were used.

The fact of the iron retorts not being capable of standing a heat sufficiently high for the distillation of coal in the most economical manner, and their liability to rapid oxidation, and even fusion, in the furnace, operated to cause the adoption of clay in the manufacture of retorts.

The clay retorts, in the face of much prejudice and opposition, gradually advanced in popularity as their merits became known, until, at the present time, their use is all but general.

Single clay retorts are burnt better and more uniformly when the ends are left open in the kiln; the backs are easily jointed in setting—care being taken to butt them close up against the mid wall.

Clay retorts when once heated do not bear "letting down" and "standing off" like those made of cast-iron, owing to their liability to crack when cooling; and for this reason a setting of one, two, or three iron retorts is useful in *very small* works during the minimum gas production in the summer season.

Different Forms of Retorts.

Retorts are made of three different shapes—viz., round, oval, and D-shaped. Formerly, rectangular or square, ear-shaped, and kidney-shaped retorts were made, but these are now entirely discarded.

The round, by reason of its shape, is the strongest and most durable; but it is not equal to the oval and D as a carbonizer.

The oval ranks next to the round in strength and durability, and exceeds it in carbonizing capabilities.

The D is the shape most commonly in use, and is considered by many gas managers to be equal to the oval as regards its power of carbonizing.

After a lengthened experience in the use of both round, oval, and D-shaped retorts, the writer prefers the oval, as being the most efficient and economical, producing during its lifetime by far the greatest quantity of gas.

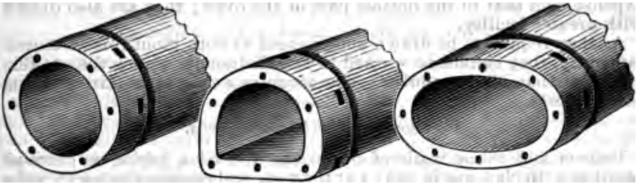


FIG. 7.

Duration of Clay Retorts.

The duration of clay retorts of course greatly depends on the setting. When the lower retorts in an oven are properly and continuously protected by seating tiles or brick arches from the direct action of the furnace, the setting will last from three to four years; otherwise—and this is nearer their average life—they will be burnt out in 15 to 18 months.

In moderate sized and in large works, each single retort should be of sufficient capacity to hold a charge of from 2½ to 3 cwt. of coal. And if Newcastle, or other caking coal of fair quality, is used, with five or six hours' charges, the yield of gas per mouthpiece should be at the rate of 5500 to 6500 cubic feet per diem of 24 hours.

Now, 18 months' continuous production, at the average rate of, say, 5500 cubic feet per mouthpiece per day of 24 hours, is equal to a total production of about 3,000,000 cubic feet of gas.

For clay retorts the heat generally ranges from 2010° Fahr. (orange) a little upwards.

Dimensions of Clay Retorts.

Clay retorts are usually made 2¾ to 3 inches thick, the flange to which the mouthpiece is bolted being 4 inches thick and 8 inches broad, the neck tapering down to the thickness of the body.

The following are useful and convenient sizes of clay retorts:—

Round . . .	16 in. diam.	Inside measure, and 9 ft. 4 in. long outside.
Oval . .	21 × 15 in. „	
D-shaped,	18 × 15 in. „	

The weight of a clay retort of the above sizes is from 14 to 16 cwt.

For very small works the following sizes are more suitable:—

Round . . .	15 in. diam.	Inside measure, and 7 ft. 6 in. long outside.
Oval . . .	18 × 12 in. „	
D-shaped,	16 × 14 in. „	

"Through" Retorts.

"Through," or double clay retorts, with a mouthpiece at each end, are made 18 to 20 feet long, being jointed together in three or four pieces.

The advantages gained in using this kind of retort are important. The accumulation of carbon is less, owing to the absence of backs. The current of air which is drawn through their interior every time they are charged tends to loosen any carbon deposit that takes place. More heating surface for carbonization is obtained without additional expense, and that in the hottest part of the oven; they are also drawn with greater facility.

As they require to be drawn and charged at both mouthpieces simultaneously, they cannot be worked in establishments where the stokers are fewer than six in number. The scoop, as a rule, is used in charging these retorts.

Fire-brick Retorts and Ovens.

Retorts and ovens made of fire-bricks and tiles, joined or grooved together with clay, are in use; but their general economy as regards the percentage of fuel required for heating, is not considered equal to that of the ordinary clay retorts In the matter of durability however, brick retorts possess a clear advantage, their life being three to four times that of the other; and though their first cost is more, this is compensated for by the saving in wear and tear. Fig. 8 is a section of a brick retort.

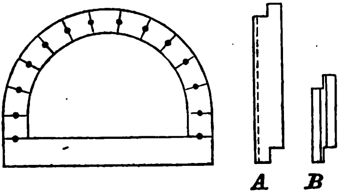


Fig. 8.

A is the bottom tile, 18 inches long by 3½ inches thick, and B one of the *bricks 9 inches by* 3½ inches.

Large ovens, 40 to 50 inches wide, are objectionable for many reasons:

A large area is exposed to the cold air every time the charge is drawn, and the time occupied is necessarily considerable. Again, there is a tendency to allow carbon to accumulate in the ovens, because in the ample space the inconvenience of the presence of a thick body of carbon is not felt by the men in drawing and charging. If the required temperature, however, is kept up under these circumstances, it must be at an excessive expenditure of fuel and labour. The greater depth of the coal, and the consequent inequality of carbonization between the inner and outer portions of the charge, is also a serious drawback to their use.

Hints on the Setting of Retorts.

The joints of the brickwork in a setting of retorts, should be as close and fine as it is possible to make them. Each brick should be dipped in water, placed in its position, and then gently, but firmly, bedded home with the hammer.

The cutting heat from the furnace can be avoided, or greatly modified, by having ample nostrils in the furnace arch.

A setting should never, when it can be avoided, be brought into use immediately on completion, as the application of strong heat to the damp clay is liable to crack the joints of the brickwork, and so hasten its destruction.

The setting ought to be allowed to stand at least 14 days, in order that it may be gradually and thoroughly dried and hardened.

Quantity of Brickwork in Retort Settings.

The retorts in a setting should be firmly supported by transverse walls, so that they may satisfactorily bear the wear and tear of working during the time they are expected to last. It is an error to suppose that the brickwork causes a diminution in the heat. Take the case of two benches of retorts set: the one with as much brickwork as is required for proper support without obstructing the draught, or unnecessarily covering the retort surfaces; and the other having the least possible quantity of brickwork, supporting (say, for example,) the retorts only at their extremities. In getting these benches in action for the first time, there can be no doubt the latter would be the first to attain the desired temperature; but although the former would require a little longer time, and the expenditure of more fuel *at first*, the superior regularity of its action over the other in distilling the gas from coal will scarcely be questioned.

No doubt the thinner the retorts themselves, compatible with strength, the better, so that the heat may the more readily pass to their interior. But the circumstances attending the retort as the vessel containing the material for distillation are not to be confounded with those appertaining to the adjacent brickwork. This, of course, need not be more than is reasonable, but it is better to err on the side of excess than too little.

Clay retorts are best 2¾ to 3 inches in thickness, according as they are made by machine or by hand, and the chief point to be observed in setting them, is to let the heat have free scope for circulating throughout the oven. With this object in mind, there should be no mistaken contraction of the nostrils leading out of the furnace; it is here where the evil in some settings exists, obstructing the passage of the heat as it is generated, and hastening the destruction of the furnace bag.

Clay retorts, 9 ft. 4 in. long, are adequately supported by four transverse supports, in addition to the back ledge and the front wall, and only one of these four need be 9 inches thick. With a setting of this description, having ample space left for the exit of the heat from the furnace into the oven, and through the flues, the best results, both as regards heating and economy of fuel, are obtained.

"Gaiting" Retorts.

On putting an oven into action, the heat should be applied gently at first, the damper being gradually opened a little more each day, until the proper temperature is attained.

When the retorts have reached a dull red heat, a light charge of coal thrown into them will assist the development of the required temperature, as well as tend to preserve them in good condition.

By carefully attending to these points, the cracking of the clay retorts on first "gaiting" may be entirely avoided.

Flues and Draught.

For a double bench, containing 10 or 12 ovens on each side, the main flue should also be double, and the internal dimensions of each division not less than 30 inches in depth by 15 inches in width. For even a lesser number of ovens the size of the flue should not vary greatly from the above.

An insufficient draught, whilst it invariably results in diminished heats, causes a waste of fuel, from the consequent incomplete combustion in the furnace, and the usual hard firing that accompanies it. The flame which is occasionally seen at the top of a retort-house chimney is significant of this defect. The flame is produced by the unconsumed carbonic oxide uniting with its due proportion of oxygen on coming in contact with the atmosphere, and by combustion being converted into carbonic acid. When the proper quantity of air is supplied to the furnace, the carbonic oxide produced is there converted into carbonic acid, and the heat thus generated is utilized for the distillation of the coal contained in the retorts.

An excessive draught through the ovens is to be avoided, as well as an obstructed one. If too much air is drawn in through between the grate bars, its effect is to reduce the heat, as well as to cause the consumption of an excess of fuel. Hence the importance of being able to control the draught by means of a damper placed at the entrance of the cross flue into the main flue on the bench.

According to the experiments of Dulong,

1 lb. of hydrogen, burning to water, yields 62,535 units of heat.
1 lb. of carbon, burning to carbonic acid, yields 12,906 ditto.
1 lb. of carbon, burning to carbonic oxide, yields 2495 ditto.
1 lb. of carbonic oxide, burning to carbonic acid, yields 4478 ditto.

NOTE.—The standard unit of heat is the amount of heat necessary to raise the temperature of a pound of water 1° Fahr.

As a rule, when firing with coke, cleaning off the fire bars once in 12 hours is sufficient. Too frequent cleaning entails a waste of coke, besides reducing the heat of the oven.

Instead of the tall chimney-stalk at the end of the retort-house, it has become the custom to erect chimneys or shafts of less altitude *immediately* over the bench, or between the benches, and rising a few *feet above the roof,* each serving for four or more double ovens on either side. These are found to produce a sufficient draught, they are more uniform and regular in their action, and their cost is necessarily less. But as they deliver the products of combustion into the atmosphere at a low level, their use should be restricted to neighbourhoods where the nuisance is unobjectionable.

When the room can be spared, it is best to erect the chimney between, and apart from, the retort-benches; so that when the latter need to be taken down and rebuilt, the chimney, being a more permanent structure, remains undisturbed.

In some works each bench is supplied with a small shaft for its own use. This is scarcely necessary, though Mr. Valon has found the arrangement useful in the facility it affords for controlling the draught where generator furnaces are used.

In many American gas-works the main flue and chimney are dispensed with altogether, the opening in the crown of the bench being found sufficient, it is said, to afford the requisite draught. Even assuming the draught to be ample for ensuring perfect heating and carbonization, which may be doubted, the objections to allowing the hot fumes to escape into the retort-house underneath the roof, are sufficiently obvious to cause the practice to be condemned.

RULE for size of retort-house chimneys under 70 feet in height: 1½ square inches of area for each lineal foot of retort, or, say, 15 inches per mouthpiece.

EXAMPLE.—Required the internal sectional area of a chimney shaft serving 12 double benches of 7 retorts, or 14 mouthpieces, each (6 benches on each side of chimney); retorts 20 feet through, total, 168 mouthpieces. Then

$$168 \times 15 = \frac{2520}{144} = 17{\cdot}5 \text{ square feet area.}$$

Dimensions for a setting of 3 large sized clay retorts, 8 ft. 6 in. long:—
  Width of oven, 5 ft. 2 in.; height, 6 ft. 3 in.; depth. 8 ft. 7 in.
  Width of furnace at grate bars, 9 in.
  Width of furnace at springing of arch, 16 in.
  Length of furnace, 30 in.
  Height from floor level to underneath the flanges of the two bottom retorts, 2 ft. 3 in.
  Number of grate bars, 2; 30 in. long each, made of 2 in. square bar-iron.

Dimensions for a setting of 5 large sized clay retorts, 9 ft. 4 in. long:—
  Width of oven, 8 ft.; height, 7 ft. 4 in.; depth, 9 ft. 5 in.
  Width of furnace at grate bars, 10 in.
  Width of furnace at springing of arch underneath the middle retort, 18 in.
  Length of furnace, 30 in.
  Height from floor line to underneath the flanges of the bottom retorts, 2 ft. 8 in.
  Number of grate bars, 2; 30 in. long each, made of 2 in. square bar-iron.

Dimensions for a setting of 7 large sized clay retorts, 9 ft. 4 in. long:—
  Width of oven, 8 ft. 6 in.; height, 7 ft. 10 in.; depth, 9 ft. 5 in.
  Width of furnace at grate bars, 12 in.
  Width of furnace at springing of arch, 20 in.
  Length of furnace, 36 in.
  Height from floor line to underneath flanges of two bottom retorts, 16 in.

Number of grate bars, 3; 36 in. long each, made of 2 in. square bar-iron.

To prevent radiation, the front wall of the oven should be a brick and a half, or 14 inches, thick. The division walls between the ovens, 2 bricks, or 18 inches thick. The back wall, when the retorts are not "throughs," a brick and a half, or 14 inches thick.

Furnace Ash Pan.

Ash pan of wrought plate-iron, 5-16ths inch, or cast-iron, 7-16ths inch thick. For a setting of seven large retorts, the length over all is 5 feet, or 4 feet not including the mouth part; 12 inches wide, and 10 inches deep, outside. (Fig. 9.)

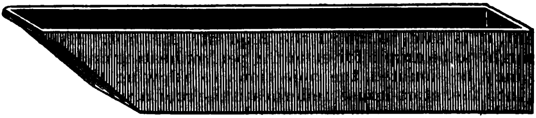


Fig. 9.

The pan should always be kept charged with water, the steam arising from which tends to preserve the furnace bars by keeping them cool; and, being decomposed in passing through the hot fuel, increases combustion.

Cost of Ovens and Settings.

The cost of a double retort-bench, with ovens to contain settings of five or seven clay retorts (whether single or double), including hydraulic main, stand-pipes, and all other ironwork, retorts, brickwork, and labour, amounts (at present prices) to from £20 to £26 per mouthpiece.

The cost of renewing an oven of five or seven clay retorts is £7 10s. to £9 per mouthpiece. An oven of three clay retorts, about £6 10s. per mouthpiece.

Cast-Iron Retorts.

Cast-iron retorts are now only employed in very small works, where the gas making is intermittent; here they are useful, as they bear letting down frequently without suffering damage. As carbonizers they are not economical, because the heat which they will stand is not high enough to produce the best results in the yield of gas from the coal. They are usually made 1⅜ inch thick, with an ordinary flange to which the mouthpiece is attached.

The round, 15 inches diameter, and D-shaped, 15 × 13 inches, are the handiest, and 7 ft. 6 in. is a convenient length. Their weight is 16 to 18 cwt. Fraser's ribbed retort (Fig. 10) is an improvement on the ordinary form.

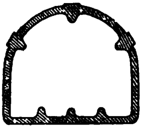


Fig. 10.

Iron retorts should always be scurfed before being let down, otherwise the unequal contraction of the incrusted carbon and the metal of the retort in cooling might cause the latter to be broken in two.

The duration of an iron retort is equal to the production of about 700,000 to 800,000 cubic feet of gas.

The best heat for iron retorts is that ranging from 1650° Fahr. (cherry red) to 1830° Fahr. (bright cherry red). Any temperature beyond this is apt to burn or soften, and so cause distortion of the retort.

Fire-clay tiles are invariably used to protect iron retorts from the direct action of the furnace heat.

In setting iron retorts a space of about 3 inches should be left in the rear, to allow for the expansion of the metal, and prevent their being forced out beyond the front wall, with the possible breakage of the ascension pipes.

Combined Settings of Clay and Iron.

In some works, combined settings of clay and iron retorts are used, the latter being heated by the surplus heat from the former. The benefits arising from their adoption are questionable.

Usual Number of Retorts in an Oven.

In average sized works, settings of five and seven retorts are usually adopted. In some of the large metropolitan and provincial works as many as 10 are placed together in one oven, with an elevated travelling stage in front, from which the higher retorts are drawn and charged.

FUEL FOR CARBONIZING.

In moderate sized works, skilfully conducted, about 3¼ cwt. of coke, or 25 per cent. of the production (say 13 cwt.) of coke per ton from Newcastle and other high-class bituminous coals, is used as fuel to carbonize one ton of coal.

In large works, under the most favourable conditions, and with the ablest management, the consumption of coke for heating the ovens may be reduced as low as 18 to 20 per cent. of the production.

In small works, one-third the production of coke is nearer the average consumption.

For the heating of brick ovens, 10 to 15 per cent. more fuel is used than is required for clay retorts.

Radiation from the bench is reduced, and fuel economized to an extent greater than might be supposed, by temporarily bricking up the furnace doors and the mouths of all retorts in beds not in use, in proximity to others in action.

Tar as Fuel.

Where tar is unmarketable, or but of low value, and there is a ready sale for coke, as is the case in some foreign towns, the former should be employed in heating the retort ovens.

Its application is exceedingly simple. When applied to an ordinary furnace, the ash-pan is first filled up with breeze; the door is then removed, and the door space bricked up, leaving two holes, one above the other, about 4 by 3 inches. The tar is supplied through the top hole, the bottom hole being for the admission of air, and to allow of the fire being stirred when required. A piece of 2-inch angle-iron, or other convenient channel, is inserted into the furnace through the top hole, and down this the tar is made to flow in a stream about 3-16ths of an inch thick.

The tar can be taken direct from the hydraulic main, in the bottom of which a 1-inch wrought-iron ferrule, having a stop-cock attached, is screwed. A ½-inch reducing coupling is then put on, and this size of pipe brought down to the side of the oven, where the tar is supplied to the trough through a nozzle of the proper dimensions.

As the hydraulic main will not supply all the tar necessary, a pipe should also be brought from a tank or cistern erected in some convenient place outside the retort-house. If this tank is placed inside the retort-house, the dust arising from the coal mixes with the tar and hinders its flow. Into this tank a supply of tar should be pumped from the tar well as required.

The great objection to the use of tar as fuel, as above applied, is that the intense heat which is generated at the point of combustion, soon destroys the arch or tiles underneath the middle retort, breaking the latter down.

As this retort, in the ordinary setting of fives and sevens, is the one usually first burnt out, it is advisable to restrict the use of tar to those ovens that have been at work for a length of time, and in which the middle retort is either much burnt or already destroyed.

To obviate the above-mentioned drawbacks, Mr. George Anderson has invented a furnace specially adapted for the consumption of tar as fuel, which admirably answers the purpose intended.

About 50 gallons of tar used as fuel will carbonize 2½ tons of Newcastle coal, or a mixture of Wigan coal and cannel, in 24 hours.

At this rate about 6 gallons of tar are equal to a sack (3 bushels) of coke.

REGENERATIVE AND GENERATOR FURNACES.

The use of gaseous fuel for heating retorts is fast emerging from the experimental stage. On the Continent more has been done in this direction than in this country, stimulated, perhaps, by the comparatively higher value of fuel there. Mr. Webber and Mr. G. E. Stevenson have done much to spread a knowledge of the value of these furnaces amongst the gas engineers of this country.

From a scientific point of view, regenerative and generator furnaces have everything to recommend them. The saving in fuel by their adoption is variously estimated at from 10 to 30 per cent. on the best results obtained by direct coke firing. But they offer other marked advantages. "Clinkering" is avoided, and consequently wear and tear of settings is reduced; the heats are higher and steadier, and being more easily regulated, they save manual labour; the charges in the retorts are carbonized more rapidly, and thus the production of gas per mouthpiece is increased, and retort-house space economised.

In the regenerative furnace, of which Dr. Siemens's is the first and *best example, the* solid fuel, whether coal or coke, is converted into a crude gas, chiefly carbonic oxide, before combustion; and the waste heat, after it has done its work in the oven, and which in the ordinary furnace is allowed to escape up the chimney, is transferred to the combustion chamber.

In the generator furnace, the solid fuel is also converted into carbonic oxide gas, but it differs from the regenerative system in this important particular, that the gas produced is mixed with the entering air whilst the latter is at the ordinary, or at but a slightly higher temperature, unassisted by the waste heat from the flue. In some instances where the air is heated, the heat is derived from the active heat within the furnace, and so to this extent detracts from the heat within the setting. Combustion is therefore less rapid and perfect, and the saving of fuel is not so marked as in the other instance.

There is quite a variety of generators in actual use, and though they vary in the details of their construction, and in their position either within the arch of the retort bench, or outside of it, the principle of action in each is identical.

The following are the chief generators: Siemens's; Liegel's, the latter well known from the description given of them by Mr. G. E. Stevenson, who introduced them into this country; Hasse's; Oechelhäuser's; Schilling's; Dietreich's, in use in some American gas-works; Klönne's and Livesey's, the last-named being in successful operation at the South Metropolitan and other gas-works.

Mr. Webber gives the following concise description of generator furnaces ("King's Treatise," vol. iii., p. 379 *et seq.*) :—

"There is much difference in the details of generator furnaces as at present constructed by various engineers, but their main features are always alike, and are remarkably simple. The usual form of the generator itself is that of a kiln, generally sunk underground or beneath the level of the charging floor of the retort-house; the capacity of the kiln, of course, varying with the amount of work it is intended to perform; but it is usually about one and a half diameters in height. The form of cross-section of the generator may be either rectangular or round, the former being easier of construction, although, according to Grahn, the latter gives better results. The generator is fed through a hole in the top, covered with an air-tight cap. The gas is usually taken off by an opening near the top. The lower part of the generator, in which the initial combustion commences, is subject to the greatest wear, especially from the formation of clinker. The air is admitted either by a grate at the bottom of the generator, as in an ordinary furnace, or by openings in the brickwork, which may be either at the sides, or in the bottom—which in that case is tapered down to the size of the opening—or by a combination of the two, as designed by Liegel, who puts a fire-grate underneath the opening in the bottom of the generator. . . . . . The generator should be lined with at least 9 inches of the best fire-bricks, between which and the surrounding walls of common brickwork, about 18 inches thick, a space of about 6 inches is left to be filled with a comparatively non-conducting material, such as asbestos, or even powdered fire-bricks, in order to diminish the loss of heat by radiation.

"The gas channel, by which the products of combustion leave the generator, varies according to circumstances, from the short connecting chamber of Liegel or Livesey, whose generators are virtually one with the retort settings, to a pipe of considerable length; but the former, or some similar plan, is obviously preferable when it is convenient to adopt it. In all cases the passage, when of any length, must be provided with a damper.

"In most cases a generator is about 3 feet to 3 feet 6 inches square, which is sufficient for heating two large settings of retorts. For one setting half this area will suffice. The body of incandescent coke is usually about 3 feet deep, although it might be reduced to half that depth without vitiating the gas produced; still it is best to keep a considerable margin, in order to avoid risk of interruption in working, which might otherwise be caused by irregularity in charging the generator, which operation would, with the sizes of apparatus above specified, be necessary at four or five hours' intervals.

"The generator may be situated anywhere in the neighbourhood of the retort bench. The furnace gases are admitted to the interior of the retort stack, guarded as much as possible from loss of their acquired heat while in transit, and there mingle with the proper quantity of previously heated air, the mixture being attended with instant combustion."

SCURFING RETORTS.

In the distillation of coal a deposit of carbon takes place within the retorts, which, if allowed to go on accumulating, eventually seriously contracts their internal area, and causes a diminution in the heats.

This deposit is due principally to the pressure produced by the resistance offered to the passage of the gas through the different apparatus.

Its removal by scurfing with chisel bars in the ordinary way is always more or less attended with damage to the retorts; the more so as they require to stand off for 6 to 12 hours, to loosen the carbon by the admission of air, before applying the bar.

Different methods of scurfing have been tried with varying success; the best probably being that by which a current of air and steam is made to impinge upon the carbonaceous deposit. The latter plan is the invention of Mr. G. W. Edge, of the Jersey City Gas-Works. The process is thus described by Mr. E. Goddard.

"The apparatus consists of a steam-pipe connected with the steam-boiler, and passing along the top of the retort benches, to which is connected a 1-inch pipe, extending out to the face of the retort mouthpiece; to this is connected a ½-inch pipe, having on it a stop-cock and union joint to connect and disconnect the pipe readily. This steam-pipe terminates at the end of a pipe 3 inches in diameter, and about 5 feet long, resting on the bottom of the retort, into which the stream rushes through a nozzle having a 3-16ths of an inch outlet, at the same time drawing with it a current of atmospheric air. A retort-lid is cut out to fit closely round the 3-inch pipe. The lid is luted on tight, and the plug removed from the top of the ascension-pipe, the retort being at a good working heat, and the apparatus is ready to perform.

"The steam should be used at a pressure of from 25 to 40 lbs. to the square inch. The rush of steam carries with it a current of atmospheric air, the cast-iron pipe becomes heated, and the steam and air rushing through it become superheated, and thus we have a compound blow-pipe of immense power, the current of which strikes with great energy on the thick portion of the carbon at the rear of the retort, but with diminished force as the returning current partially charged with the products of combustion approaches the front end of the retort, where the carbon is thin, in order to pass out through the ascension-pipe. If the retorts are thickly coated with carbon (say several inches thick), on the first application of the apparatus it will require several hours to clean them out; but when the retort is once decarbonized, one hour's application every thirty days will be found amply sufficient to keep the retort clear of extraneous carbon."

After all, the best plan of obviating the nuisance is to *prevent* the deposit as much as possible, by minimizing the dip, by employing an exhauster to reduce the back pressure; and in very small works where this is not available, by cleaning the surface of the retorts with a rounded steel scraper every time they are drawn.

TABLE OF COLOURS

Corresponding to various High Temperatures. (*Pouillet*).

	Fahr.		Fahr.
Faint red	977°	White heat	2370°
Dull red	1290°	Bright white heat	2550°
Brilliant red	1470°	Dazzling white	2730°
Cherry red	1650°	Melting point of cast-iron—	
Bright cherry red	1830°	White	1920° to 2010°
Orange	2010°	Grey	2010° to 2190°
Bright orange	2190°		

The effect of a too low heat in the retorts is to diminish the gaseous products, the chief result of the distillation being the production of tar.

TABLE,

By Miller, exhibiting the amount and specific gravity of the gas obtained from two bushels of coal during each of five hours' heating in an ordinary retort; showing the importance of restricting the time during which the coal is subjected to the action of heat in the manufacture of gas. The rich hydrocarbons diminished, and carbonic oxide and hydrogen increased in quantity as the experiment progressed.

	Cubic Feet.	Specific Gravity.
In the first hour	345	·677
In the second hour	203	·419
In the third hour	118	·400
In the fourth hour	54	·322
In the fifth hour	20	—

With cannel the carbonization takes place in considerably less time than with ordinary coal.

TABLE

Exhibiting the Qualities of Gas at Different Periods of Distillation. (*Dr. Henry.*)

From Half a Ton of Wigan Cannel.

Time from Commencement of Distillation.	100 Measures of Impure Gas contain		100 Measures of Purified Gas consist of			100 Measures of Purified Gas	
	Sulphuretted Hydrogen.	Other Compounds of Nitrogen and Hydrogen.	Olefiant Gas.	Other inferior Gases.	Nitrogen.	Consume Oxygen.	Give Carbonic Acid.
½ an hour.	½	5½	16	64	20	180	94
1 hour.	3	3½	18	77¼	4¾	210	112
3 hours.	2½	2½	15	80	5	200	108
5 "	2½	2½	13	72	15	176	94
7 "	2	2½	9	76	15	170	83
9 "	½	2½	8	77	15	150	73
10½ "	..	2	6	74	20	120	54
12 "	..	½	4	76	20	82	36
From Half a Ton of Common Wigan Gas Coal.							
1 hour.	3	3	10	90	..	164	91
3 hours	2	2	9	91	..	168	93
5 "	3	2	6	94	..	132	70
7 "	1	3	5	80	15	120	64
9 "	1	2½	2	89	9	112	60
11 "	1	1	..	85	15	90	43

RATE OF PRODUCTION OF GAS

FROM 2 CWT. OF WIGAN COAL IN AN EXPERIMENTAL RETORT.

	Cubic Feet.
½ hour	275
1 "	245
1½ hours	200
2 "	140
2½ "	80
3 "	40
3½ "	20
4 "	15
Total	1015

RETORT MOUTHPIECES.

The following are the details of a mouthpiece for an oval retort *21 in. by 15 in.*, and will serve as a model for any other size and shape, *allowance being* made for varying dimensions. (See Figs. 11 to 14.)

Depth from front to back, over all, 15 in.
Thickness of metal in front portion, ⅝ in.
Ditto in lip, 1 in., and planed level.
Ditto in flange, 1 in.
Width of flange in front, 8⅜ in.
Ditto at back, 4 in.
Number of bolt holes, 8; diameter, 1 in.
Ear-box on each side, with slot 2 in. by ⅝ in.
Socket, to receive end of ascension-pipe, 5 in. in height, and 6½ in. diameter inside; centre 5 in. from front.
Bolts, for securing mouthpiece to retort, 8; diameter, ⅞ in.; screwed and nutted at both ends.
Lugs, of wrought-iron, 14 in. long, 2 in. broad, and ⅝ in. thick; one with jaws and pin for hinging cross-bar, the other cranked and notched, as in Fig. 14. Slit at opposite end, 2 in. long, ¼ in. wide; wedged to ear-box.
Cross-bar, of wrought-iron, 25 in. long, 2 in. broad at each end, and ½ in. thick. Middle part 2½ in. broad, swelled out to 2 in. thick, with 1 in. screwed hole through centre.
Screw, 10 in. long, with square thread 7 in. of its length.
Cross-handle, 14 in. long, ¾ in. round-iron.
Lid, ¼ in. thick. plate-iron, dished, with lug on each side.

Various devices for dispensing with the screw and its slow action have been introduced. Amongst these, Box's retort-lid fastener, made by Geo. Waller and Co., and Storer and Pugh's lever handle may be specially named.

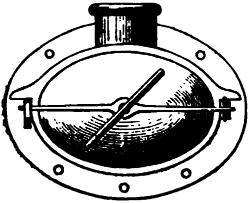


FIG. 11.

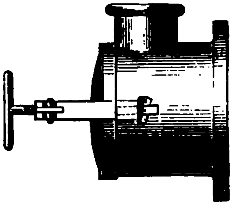


FIG. 12.

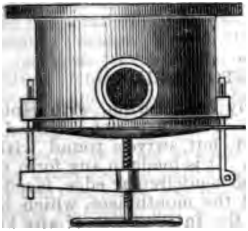


FIG. 13.

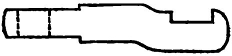


FIG. 14.

CEMENTS FOR JOINTING RETORT MOUTHPIECES.

For clay retorts—

Three-fourths by weight of fire-clay.
One-fourth by weight of iron borings.

When ready to connect, mix with ammoniacal water. Use no sulphur.

20 lbs. gypsum (sulphate of lime) made into a pulp with water.
10 lbs. iron borings saturated with a strong solution of sal ammoniac.
Mix well together till of a consistency fit for use.

In fixing the mouthpieces to clay retorts, the flange or face of the retort should be notched all over with a sharp-pointed hammer, or a slight channel cut all round (this is best done by the retort maker in course of manufacture), for the cement to bed into when the bolts are screwed up.

CEMENTS FOR JOINING THE ENDS OF CLAY RETORTS.

10 lbs. gypsum made into a pulp with water.
20 lb. iron borings saturated with a strong solution of sal ammoniac.
Mix well together till of a consistency fit for use.

Some engineers use fire-clay alone, mixed with water to the consistency of mortar.

For iron retort mouthpieces—

2 lbs. fine clean iron borings.
1 oz. sal ammoniac.
1 oz. flowers of sulphur.

Mix together and keep dry. When required for use, add water to bring the mixture to a proper consistency.

CEMENTS OR LUTING FOR RETORT-LIDS.

Ordinary lime, or spent lime from the purifiers mixed with fire-clay or common clay, and worked up into mortar.

The following makes a tough persistent luting:—

1 part lime.
2 parts moulding sand.

Ground up together, with water, in a mortar mill.

SELF-SEALING RETORT LIDS.

The self-sealing retort-lid, invented by **Mr. Morton**, with Holman's eccentric fastener, is extensively used. The lid is not removed from the mouthpiece in charging the retort, but swivels round with the hinged cross-bar to which it is secured. It is made in any form to suit the shape of the retort, with upturned semicircular edge, faced true. This pressing against the flat edge of the mouthpiece, which is also *faced,* makes a gas-tight joint without the intervention of any kind of *luting.*

Other self-sealing retort lids are Tassie's, made with a steel ring let into a groove in the face of the mouthpiece; Parlby's and Grice's, having a projection on the edge of the lid fitting into a recess on the face of the mouthpiece; and Somerville's, which consists in the contact of the outside of the rim of the lid with the inner conical lip of the mouthpiece.

RETORT-HOUSE TOOLS.

Shovels with riveted handles are not good in or about a retort-house. The heat soon causes the wood to dry in, and the rivets give way and become jagged, lacerating the hands of the men who use them. Socketed handles are much the best.

A good handy-sized shovel for charging retorts of the ordinary size is one 16 inches long by 11 inches wide. Firing shovels (for coke) are best made an inch wider. Both should be well turned up at the sides.

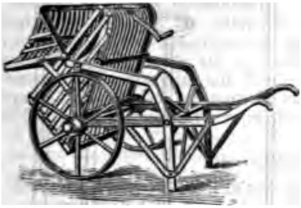


FIG. 15.

For charging through retorts, the scoop, Fig. 16, is frequently employed.

Other retort-house tools consist of the discharging rake, Fig. 17; auger, Fig. 18; ash-pan rake, and shovel, Figs. 19 and 20; fire tongs, Fig. 21; and pricker, Fig. 22. [See next page.] Price's coke and coal barrow, Fig. 15, is a useful and serviceable adjunct to the retort-house.

CHARGING AND DISCHARGING RETORTS BY MACHINERY.

The difficult problem of applying machinery to the charging and discharging of retorts, is one which has occupied the minds of gas engineers from the very introduction of gas-lighting, and its solution has been attempted with varying success. Out of about twenty different contrivances that have been invented for the purpose, not more than four or five remain in use at the present time, and these only to a limited extent.

The hydraulic stoker invented by Mr. W. Foulis, and the combined hand and machine stoker of Mr. J. West, are both in use at the Manchester Corporation Gas Works. The latter has also been adopted at Maidstone, Portsea, Ipswich, Burnley, and several other works. Mr. West has also patented the application of compressed air to the propelling of his machinery, and this is successfully at work at the Manchester and the South Metropolitan Gas Works.

Mr. Warner's machinery is employed at South Shields; and the ingenious steam stoker, the invention of Mr. A. Q. Ross, of Cincinnati, U.S. America, is in use at various works in the States.

Clegg attempted to perfect an arrangement by which a continuous supply and discharge was effected, and though he did not succeed in producing an economical and satisfactory apparatus, it is greatly to be desired that future efforts in the same direction may be crowned with success.

F 2

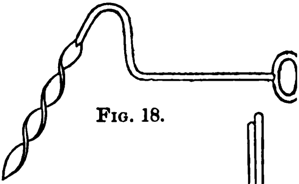


FIG. 18.

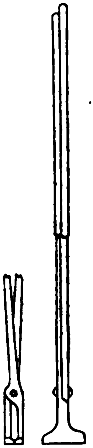


FIG. 21.

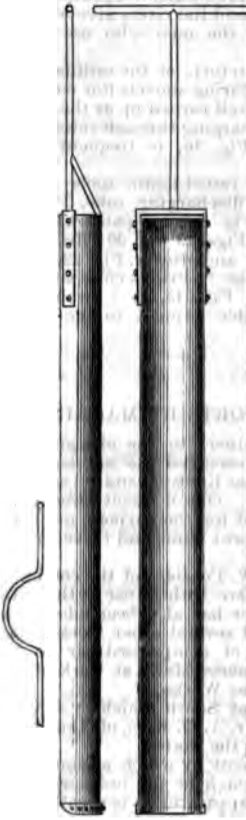


FIG. 16.

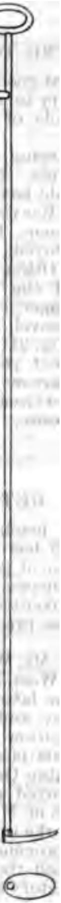


FIG. 17.

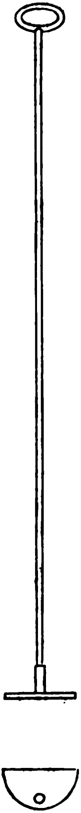


FIG. 19.

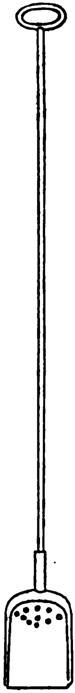


FIG. 20.

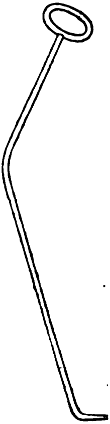


FIG. 22

ASCENSION OR STAND PIPES.

These should not be less than 5 inches internal diameter, with flange at upper end.

Diameter of flange, 10½ inches.

Bolt-holes, 4 in number, centre to centre across, 8¼ inches.

Diameter of bolts, ⅝ of an inch.

The best caulking material for ascension-pipes at their junction with the mouthpiece socket, is ordinary ground fire clay, or slaked lime, made of the consistency of putty. These, when pressed down into the space between the spigot and socket, make a perfectly tight and durable joint, and are easily removed when the retorts need renewing. On the other hand, when the joints are caulked with iron cement, the labour in cutting it out and the risk of splitting the socket are considerable.

Choking of Ascension-Pipes.

Ascension-Pipes occasionally become choked, to a greater or less degree, with thick tar, pitch, and other carbonaceous matter. When this occurs, let as many as can be spared at once stand off for a shift (provided the retorts are in condition to admit of this), drawing the charge, and removing the bonnet or plug from the top of the bridge-pipe. The heated air making its way through the smallest aperture will thoroughly clear them of the obstruction.

Preventive of Choking.

Keeping the pipes cool is the best preventive of choking. This may be accomplished to a great extent by making the front walls of the ovens 1½ bricks thick, so preventing undue radiation from the bench, and having the mouthpieces of the retorts so constructed as to allow of the pipes standing 6 or 8 inches away from the front wall of the oven.

BRIDGE AND DIP PIPES.

Internal diameter of bridge and dip pipes, 5 inches.

Height of bridge pipe, 16 inches.

Width, centre to centre, 21 inches.

Connecting flanges, diameter, 10½ inches.

Bolt-holes, 4 in number, centre to centre across, 8¼ inches.

Diameter of bolts, ⅝ of an inch. (See Fig. 23.)

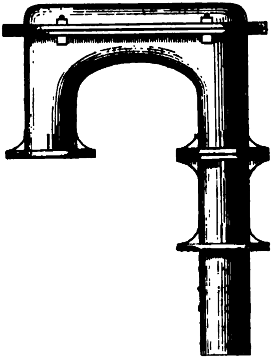


Fig. 23.

HYDRAULIC MAIN.

Dimensions and Form.

The hydraulic main, as a general rule, even in small works, should not be less than 18 inches in width at the water level.

In section it may be either D-shaped (with the flat side upwards), square, oblong, or round. The three former shapes are usually adopted in preference to the round, allowing more gas space than the latter. (Figs. 24, 25, and 26.)

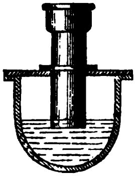


FIG. 24.

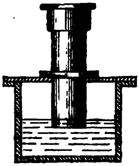


FIG. 25.

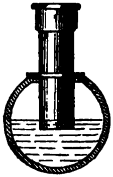


FIG. 26.

The Livesey Hydraulic.

This, in section, resembles the frustum of a cone, but is slightly convex at the sides, and dished at bottom to the extent of 2 inches below the end of the dip-pipe. It is smaller, and consequently lighter, than the mains generally in use; but at the water level the area is equal to the old forms. The chief object of the modification in form is to prevent the accumulation of thick tar and crystals of ammonia; this is accomplished by allowing only a shallow depth of liquid, and this being kept in motion or circulation by the issuing gas, all deposit is prevented. (Fig. 27.)

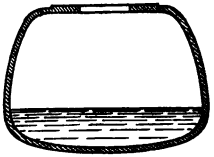


FIG. 27.

With the same object in view, Mr. Livesey has reduced the bottom space in his existing old-fashioned D-shaped mains, by placing therein a plate of No. 10 gauge sheet-iron, also dished to the extent of 2 inches below the end of the dip; the space underneath being first filled up with sand.

Wrought-Iron Hydraulic Mains.

Wrought-iron hydraulic mains, made of 5-16ths of an inch boiler plate sides and bottom, and 7-16ths of an inch top, are being generally adopted, owing to their lightness and strength, and are an improvement on those made of cast-iron, which are usually 3-4ths of an inch thick.

Position of the Hydraulic Main.

The hydraulic main may be either erected on standards placed on the retort-bench; on girders attached to the backstaves, which are lengthened so as to reach above the bench for that purpose; or on cast-iron pillars in front, and quite detached from the brickwork.

When placed upon the bench, it is liable to be disturbed by the contraction and expansion of the materials composing the latter; and when the bench needs rebuilding, it is an obstacle to the progress of the work. On the other hand, when erected on pillars in front, these are slightly in the way, though placed opposite the walls dividing the several ovens; and the main itself is more exposed to the heat of the flame from the retorts in charging.

In some instances the hydraulic main is placed against the retort-house wall, being supported on brackets or cantilevers attached thereto. This plan necessitates a strong wall to bear the weight of the main and its contents, and also a long length of pipe overhead, fixed in an inclined position, attached at one end by a bend to the ascension-pipe, and at the other to the dip-pipe on the main.

In addition to the hydraulic main, a second main is sometimes laid along the bench, and connected to the former at the water level, at each bench or oven, by a pipe with a valve upon it for closing when necessary. This secondary main conveys the gas and liquid products from the retort-house, and admits of the isolation of the hydraulic main over each setting of retorts. By this arrangement it is easy, in case of any disturbance of the bench through settlement or otherwise, to restore the several short lengths of hydraulic main to the true level. It may, however, be doubted whether the additional expense the arrangement involves is compensated for by the advantages which it offers.

The Dip in the Hydraulic Main, and the Effect of Keeping the Gas in Contact with the Tar.

A simple gas is usually described to be a permanently elastic fluid, under the ordinary conditions of temperature and pressure. Coal gas, as it is compound in character, does not answer to that description. When it has been distilled from the coal by the agency of heat, and issues from the retort up the ascension-pipe into the hydraulic main, there is carried in suspension, along with the permanently gaseous fluids, a number of hydrocarbon and other vapours, which condense at temperatures varying from about 160° or 140° Fahr. downwards.

These hydrocarbons contribute largely to the illuminating power of the gas, and it is therefore desirable to retain them in the permanently gaseous form. Some of them, especially such as are of the greatest density, are reduced to the liquid state by the mere mechanical reduction of their temperature; whilst others of equal specific gravity, and many of those of lower density, undergo a change from the gaseous to the liquid condition, by reason of the solvent or absorbent action of the liquid contents of the hydraulic main, through which, by reason of the dip, they have to pass; or with which, in the absence of the dip, they come intimately in contact. The former may be classed as hydrocarbon vapours, the latter as gaseous hydrocarbons. It is thus evident that the process of condensation begins at the hydraulic main, the results there produced materially affecting the quality of the gas.

Those hydrocarbons that are changed to the liquid form by this slight diminution of temperature, it is probably impossible to retain in the gas under any circumstances whatsoever. With the more volatile, though still heavy, hydrocarbons, the case is different; the power of retaining them in the permanently gaseous form is within the bounds of possibility, and these are, therefore, of the greatest interest to the gas manufacturer.

A further class of hydrocarbons are not liquefied at all under ordinary conditions, and there should never be any difficulty experienced in keeping them in the gaseous state.

Of the second class of hydrocarbons, viz., those which, though of high specific gravity, it is practicable to retain in the gaseous form, we shall now speak. Their retention in the gas, and how this is most likely to be accomplished—or at least how best to remove all impediments to that end—greatly concerns the gas-maker. It has been assumed that the mere reduction of temperature between the retort-mouth and the hydraulic main will not affect their gaseous condition. Under what other circumstances, then, are they condensed in the hydraulic main, and in the subsequent mains leading to the condenser? The answer is clear, and is what has been already indicated, viz., by the affinity which exists between them and the already liquefied hydrocarbons present in the mains.

Some remarkable notes corroborating these views in several important particulars are recorded by Mr. W. Young, being the result of a number of experiments made by the late Mr. Cusiter in 1868, on the absorption of the light-giving constituents of coal gas by the heavy hydrocarbon oils, his attention being drawn thereto when experimenting with glycerine as a substitute for water in gas-meters.

After having satisfied himself that the disadvantages attending its use were not compensated by its advantages, he turned his attention to other liquids which might, he thought, be suitably applied for the like purpose. One of them was mineral oil of 840° specific gravity. The effect of this with 28-candle gas was to reduce the illuminating power to 14 candles; and with gas of 35 candles to 16·1. During the winter of 1873–74 he repeated the experiments, and made some additions to the number. Mr. Young deduced from these experiments various facts of general interest, having reference to the means afforded of ascertaining the percentage of hydrocarbons in a given quality of gas.

In a further communication on the same subject, Mr. Young showed that so great is the solvent action of heavy hydrocarbon oil (boiling point 180° Fahr.) that hydrocarbons, such as olefiant gas, which are permanent gases at ordinary temperatures, may be reduced to the liquid form in passing through it. He further showed that if, instead of allowing the gas and mixed hydrocarbons to cool together, the gas, saturated with the vapour of the lighter hydrocarbon liberated by heat from the mixed fluids, were transferred into a separate vessel, thereby preventing the heavier hydrocarbon from coming in contact with, and reabsorbing the lighter, the gas would remain saturated with the vapour from the more volatile fluid.

These important facts lead to but one conclusion, viz., that the practice of allowing the whole of the tar to flow along with the gas through an extensive range of pipes to the condenser, both being gradually cooled together in the passage, is founded on an erroneous estimate of the results that follow thereon, is highly objectionable, and must be condemned.

Mr. R. H. Patterson, with that wise insight which characterizes his investigations, has given expression to his views on this subject in an able article "On Keeping Gas in Contact with Tar," in which the objectionableness of the practice is very clearly shown.

The cooling of the gas gradually is a provision the wisdom of which is unquestionable, and the plan of causing it to make the circuit of the retort-house in pipes is probably the best method of accomplishing that object; but the deposited tar in the hydraulic main and in the foul *main at the point,* as near as can be ascertained, when its temperature *has fallen to about* 110° or 100° Fahr.—the temperature at which its absorbent powers come into most active operation—should be drained away direct to the tar-well by its own separate conductor.

The chief advantages believed to accrue from lengthened contact of the gas with the tar are, first, the absorption by the latter of naphthaline that would otherwise be carried forward to be deposited, by reason of the decrease in temperature and other causes, in the mains on the works, and even in the street mains, service pipes, and the internal fittings on the premises of consumers; and, secondly, the absorption also of a considerable portion of the obnoxious sulphur and other compounds.

These advantages will not be forfeited by the direct removal of the bulk of the tar, because sufficient light tar will be left in the circuitous gas main to absorb any excess of naphthaline vapour present, and even to assimilate a portion of the sulphur and other impurities. Besides this, as the general effect will be to leave a larger proportion of the gaseous hydrocarbons in the gas, these, by virtue of the power which they possess in common with the liquid hydrocarbons, of assimilating—and, in this special case, of suspending—other hydrocarbons, will necessarily assist in retaining in the permanent form a portion of the naphthaline that would, in presence of the greater bulk of tar, have been liquefied and deposited. By a similar train of reasoning, the fact of the inferior quality of the tar produced from the richer cannels, as compared with that from coal, may be explained.

In dealing with this subject, it has been assumed by some that no absorbent action is likely to result so long as the tar with which the gas is in contact is at a temperature of about 100° Fahr., and above; and that, therefore, the dip in the hydraulic main causes no diminution in the amount of hydrocarbon gases present. It has even been assumed that the tar in the main gives off a proportion of hydrocarbon vapour, and in this way increases the illuminating power of the gas. On reflection, however, it will be plain that this argument is altogether untenable, for it is scarcely possible to conceive that hydrocarbons which have already been liquefied at a high temperature, can again, at a lower temperature, assume the gaseous or vaporous form. There can be no doubt that the heavy tars have an absorbent action, less or more, at all temperatures, being greatest at the lowest; and this being so, the passage of the gas through such tars by reason of the dip in the hydraulic main, must have a prejudicial effect upon the illuminating constituents of the gas. On the other hand, where means are employed for removing the heavy tars from the main as rapidly as possible after they are deposited, the disadvantages of the dip into the lighter liquors contained therein are reduced almost to *nil*. This is especially true where the arrangements are such, that, by careful adjustment, and an adequate area at the water level, the dip is limited to about three-fourths of an inch.

Such being the case, considering the easy application of the dip, its economy, its self-acting regularity, its comparative immunity from failure, and the safety attending its use, it is questionable whether any of the many appliances for dispensing with it, offer sufficient inducements to compensate for the advantages enumerated.

TEMPERATURE OF GAS IN THE RETORTS.

The reason of the comparatively low temperature of coal gas as it ascends to the hydraulic main, after being in contact with the intensely heated surfaces of the retorts in which it is generated, is not apparent at a cursory glance.

At first sight it would appear as though the action upon the gas in a retort would be similar to the effect upon air by the ovens of blast furnaces, where a million cubic feet are heated in the space of an hour to 633° Fahr., the melting point of lead.

So far from this being the case, the permanent gas at its highest temperature does not probably exceed 135° Fahr., though generated in a heat usually reaching 2200°.

The reason of the difference in the effect produced in the two instances given, is explained by the fact of the rapid absorption of heat by the volatile constituents of the coal in assuming the gaseous form, this heat becoming latent in the gas as in the case of the formation of steam in an open boiler.

The following is a record of experiments made by the writer to determine the temperature of the gas as it issues from the retort:—

Experiment No. 1.

This experiment was conducted entirely under the usual conditions of working.

Clay retort, 20 feet through, one in a setting of seven.

Heat, bright cherry red.

Hole drilled in both ascension pipes 3 feet above the mouthpiece.

Retort charged with 4 cwt. of cannel.

Temperature indicated on insertion of thermometer through the hole on one side of bench, 193° Fahr.

Temperature indicated on insertion of thermometer through the hole on the other side 510° Fahr.

The temperatures indicated were clearly not those of the gas. In attaining the higher temperature especially, the mercury rose by starts at the rate of 3° to 5° at once, evidently caused by hot particles of solid carbon, or other solid or semi-fluid substances coming suddenly in contact with the bulb of the thermometer.

The remarkable difference in the temperature of the two sides is accounted for in this way:—On the side in which 193° was indicated the dip-pipe was probably sealed to a greater depth in the hydraulic main, and consequently the flow of gas was neither so abundant nor so rapid on that side as on the other. This was evidenced by the thermometer on withdrawal being found less thickly coated with tar than in the other case. The gas was in a more quiescent state, and therefore there was not the same rush of hot, solid particles against the bulb to raise the temperature abnormally.

Experiment No. 2.

The conditions were the same as in the previous instance; but instead of inserting the thermometer directly through the hole in the ascension-pipe, the end of a piece of india-rubber tube 12 inches long, ¾ inch bore, was pressed against the orifice, and the gas allowed to flow in a stream through the tube. The object of employing the tube was to obviate, if possible, the contact of the semi-solid or semi-fluid substances previously referred to.

The result was:—Temperature indicated on one side 250°, ditto on the other side 324°.

The rise of the mercury was still somewhat irregular, and the instrument, so far as inserted, was again thickly coated with tar.

Experiment No. 3.

One end of the through retort was now bricked up, being made perfectly gas-tight, the gas passing away by one only of the ascension pipes: in point of fact the retort was made single instead of through.

In a short, double-flanged piece of the ascension-pipe, within 8 inches of the top of the mouthpiece, were inserted six layers of iron wire netting, cut into discs, accurately fitting the bore of the pipe. Three of these discs had meshes one-eighth, and the other three three-sixteenths of an inch gauge, and the discs were kept three-fourths of an inch apart by sheet-iron rings, inserted edgeways into the pipe.

The charge, 2 cwt. of cannel, thrown into the retort, happened to be taken from a heap that had been exposed to the rain, and there was considerable moisture present.

The hole through which the thermometer was inserted, as in the previous experiments, was 3 feet above the mouthpiece.

The following were the temperatures indicated :—

Time. Minutes.	Temp. Fahr. Degrees.	Time. Minutes.	Temp. Fahr. Degrees.
10	200	55	177
15	198	60	174
20	195	65	172
25	192	90	160
30	190	105	158
35	188	120	150
40	184	130	150
45	182	140	148
50	179	150	142

Through all the higher teperatures, down to 172°, steam was condensed into drops upon a piece of paper held in the stream of gas issuing from the hole. Tar, though not entirely absent, was nearly so, the instrument on each withdrawal being but slightly coated. The temperature, with but few exceptions, rose with great regularity from that of the atmosphere of the retort-house (74°) to the rates observed, showing that the semi-solid particles, which were evidently the cause of the high temperatures previously indicated, had been nearly all arrested by the wire netting.

The higher temperatures, I am of opinion, were due to the presence of steam in the gas in varying proportions, and this latter would be caused by the moisture in the coal.

Experiment 4.

The retort was again charged, this time with 2 cwt. of cannel in a drier state. All the other conditions were as in the previous trial.

The following were the results obtained :—

Time. Minutes.	Temp. Fahr. Degrees.	Time. Hours.	Temp. Fahr. Degrees.
2	158	1¾	129
7	174	2	123
12	177	2¼	122
17	172	2½	119
22	171	2¾	118
27	169	3	116
32	168	3¼	113
75	141	3½	110
90	134		

During the first half hour of the charge the presence of steam, mixed with the issuing gas, was indicated as before, but less abundantly, though still, doubtless, affecting the results obtained. When the temperature of the gas within three feet of the mouthpiece was at 174°, it stood at 132° in the bridge pipe, 14 feet higher up.

It may be suggested that the effect of passing the gas through the wire netting would be to lower the temperature of the gas, just as the wire gauze on a Davy lamp reduces the temperature of the flame impinging against it. The conditions in the two cases, however, are entirely different. The meshes were sufficiently large to admit of an easy passage for the gas, and the metal would be immediately covered with a thick coating of tar, virtually producing insulation. In addition to that, the temperature within six inches of the front of the bench was 208°, and the metal of the ascension pipe, as well as the inserted wire netting would, as a rule, be above the temperature of the gas. The results of these researches will be found to confirm, in a remarkable manner, the deductions of earlier investigators.

Temperature of the Gas in the Bridge Pipe, 14 *feet from the Retort Mouthpiece.*

Experiment.	2-Cwt. Charges.	Temp. of the Gas.
No. 1 ..	.. retort charged 1 hour ..	.. 135° Fahr.
„ 2	„ „ 3 hours ..	.. 116° „
„ 3	„ „ 4½ hours ..	.. 119° „

CONDENSATION.

Extent of Condensation.

The degree of condensation to which coal gas should be subjected after leaving the retorts, and before entering the purifiers, has never been determined with that scientific accuracy which the importance of the subject demands.

The axiom that "thorough condensation is half the purification," is too sweeping in character to be serviceable or safe as a guide. The term "thorough," as applied to the condensation of coal gas, still remains an indefinite quantity, though the well-directed and carefully conducted inquiries of the first Referees in the metropolis (the results of which are embodied in their admirable and valuable reports) have led to a more exact knowledge on this and the other branches of gas purification.

With respect to one point there cannot be two opinions—viz., the necessity of guarding against a lower temperature in the gas than 50° Fahr. If condensation is carried beyond this, the lighter hydrocarbons are in danger of being deposited, and the gas impoverished.

In the following table the bad effects of excessive refrigeration are shown.

TABLE

Exhibiting the Loss of Illuminating Property in Coal Gas on Exposure to the Temperature of Freezing Point, 32° Fahr.

Name of Gas.	Hydrocarbons condensed from 1000 Cubic Feet of Gas on Exposure to a Cold of 32° Fahr.
Boghead cannel	4·42 cubic feet.
Ince Hall ditto	·37 „
Methyl ditto	·33 „

From the above it appears that the richest gas suffers the greatest deterioration on being subjected to cold.

Rapid or Sudden Condensation.

Experience has sufficiently proved that rapid or sudden, as well as excessive, condensation, is an evil to be avoided; and that to prevent the deposition of naphthaline in the pipes, and preserve some of the richer illuminants, the gas should be allowed to travel in contact with the lighter tars until the latter are reduced in temperature to about 100° Fahr. before separation takes place.

With this object in view, the pipe leading from the hydraulic main may be carried with a gradual inclination round the interior of the retort-house or other convenient building, and from thence to the condenser; provision of course being made to allow the thicker tar to run off at a point near to the hydraulic main. By this arrangement the gas is slowly reduced in temperature, and some of its most valuable light-giving hydrocarbons, which would otherwise be condensed, are retained within it in the permanent state.

. . . .

Temperature as affecting Registration.

The make of gas, as indicated by the station-meter, is materially affected by the temperature at which it is registered.

At the temperature of 60° Fahr., with the barometer at 30 inches, gas is at its standard volume; and as all aëriform bodies expand $\frac{1}{480}$ of their bulk at 32° Fahr. for every additional degree of temperature, or about 1 per cent. for 5°, it follows that a quantity of gas, say 10,000 cubic feet, registered at 60°, would at 70° become 10·196, and at 80° 10·393.

The quantity of heat which will raise a cubic foot of water one degree, will raise 2850 cubic feet of gas or atmospheric air to the same extent.

In instituting a comparison between the production per ton of material at different works, and in testing the productive value of different coals, it is, therefore, necessary to take into account the temperature of the gas at the time of measurement. In ascertaining the specific gravity of gas, and in conducting photometrical observations, the same care should be taken to note the temperature of the gas at the time and place of making the experiment.

TABLE.—EXPANSION OF AIR AND PERMANENT GASES BY HEAT.

Temp. Fahr.	Expansion.	Temp. Fahr.	Expansion.	Temp. Fahr.	Expansion.	Temp. Fahr.	Expansion.
32	1000·0	52	1041·6	72	1083·3	92	1125·0
33	1002·1	53	1043·7	73	1085·4	93	1127·1
34	1004·2	54	1045·8	74	1087·5	94	1129·1
35	1006·2	55	1047·9	75	1089·6	95	1131·2
36	1008·3	56	1050·0	76	1091·6	96	1133·3
37	1010·4	57	1052·1	77	1093·7	97	1135·4
38	1012·5	58	1054·1	78	1095·8	98	1137·5
39	1014·6	59	1056·2	79	1097·9	99	1139·5
40	1016·6	60	1058·3	80	1100·0	100	1141·6
41	1018·7	61	1060·4	81	1102·1	110	1162·5
42	1020·8	62	1062·5	82	1104·1	120	1183·3
43	1022·9	63	1064·5	83	1106·2	130	1204·1
44	1025·0	64	1066·6	84	1108·3	140	1225·0
45	1027·1	65	1068·7	85	1110·4	150	1245·8
46	1029·1	66	1070·8	86	1112·5	160	1266·6
47	1031·2	67	1072·9	87	1114·6	170	1287·5
48	1033·3	68	1075·0	88	1116·6	180	1308·3
49	1035·4	69	1077·1	89	1118·7	190	1329·1
50	1037·5	70	1079·1	90	1120·8	200	1350·0
51	1039·6	71	1081·2	91	1122·9	212	1375·0

TABLE

Showing the Relative Effects of Water and Air as Cooling Agents for the Condensation of Gas. (Peclet.)

Excess of Temperature in the Gas over the Atmosphere.	Quantity of Heat lost by a Square Unit of Exterior Pipe Surface. When radiating in Air.	When plunged in Water.
For an excess of 10°	8	88
" " 20°	18	266
" " 30°	29	5,353
" " 40°	40	8,944
" " 50°	53	13,437

Water is thus shown to be the superior cooling agent, requiring the exposure of much less radiating surface than air; but, for the reasons already adduced, the latter is found to be the more suitable medium for the condensation of gas, except under the special conditions noticed hereafter.

TABLE

Giving the Mean Temperature (Fahr.) of every Tenth Day in the Year in the Central District of England. (Box.)

	1st.	11th.	21st.		1st.	11th.	21st.
	Deg.	Deg.	Deg.		Deg.	Deg.	Deg.
January	36·5	35·6	37·1	July	61·2	61·5	62·0
February	37·2	37·5	38·5	August	62·5	61·7	60·6
March	40·1	41·0	41·9	September	58·8	57·4	55·5
April	43·6	45·0	47·0	October	53·5	51·4	49·0
May	50·0	51·3	53·8	November	46·4	44·0	42·0
June	56·4	57·5	59·8	December	41·7	40·2	38·4

CONDENSERS.

Atmospherical Vertical Condenser.

The ordinary atmospheric condenser (Fig. 28) consists of a series of pipes, usually 18 feet long, put together in two lengths, and placed upright, through which the gas passes up and down alternately. These enter a rectangular cistern at bottom, in which the condensed vapours are deposited, and from whence they flow to the tar well. At the top is another cistern, containing water to seal the movable hoods covering each pair of pipes, and for further refrigeration, should such be required, in warm or sunny weather, small streams being made to trickle down the exterior surface of the pipes.

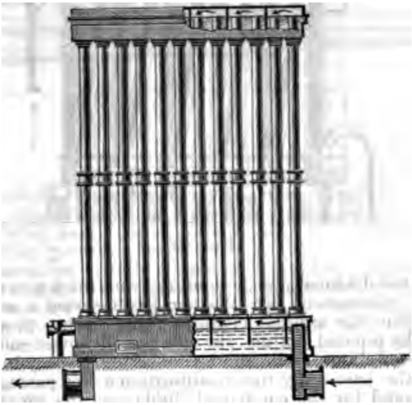


FIG. 28.

Atmospherical Annular Condenser.

The annular condenser is one of the most efficient atmospherical condensing apparatus for gas that has yet been devised. In Kirkham's Condenser, as improved by Wright (Fig. 29), the pipes are placed in the vertical position, and are of large diameter, each one enclosing a smaller pipe; the two forming an annular space through which the gas is made to flow. Other pipes, placed diagonally, connect the top and bottom of the condensing columns alternately. By this arrangement the gas passes through the annular space always in the downward direction, whilst the current of air moves upwards through the interior ventilating pipe. In cold weather movable covers are placed over the latter, or butterfly valves are fixed at the foot, for closing, to prevent the air draught, which might otherwise reduce the temperature of the gas below the desired standard. A small pipe is connected to the bottom of each column, to carry away the deposited tar and water into a main laid alongside the condenser, and leading into the tar well.

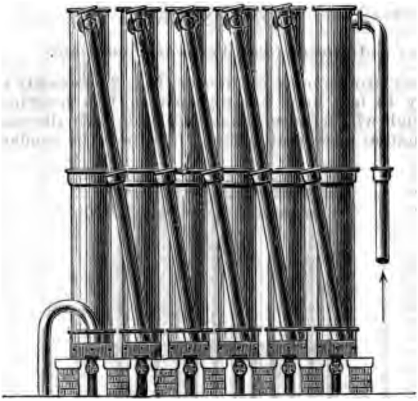


FIG. 29.

Instead of the diagonal pipe, extending from the top to the bottom of each column alternately, Mr. Warner has inserted a mid-feather or partition, within the annular chamber; this reaches to within a short distance of the top and bottom, the space at the lower end being sealed by the deposited fluids, and a short connecting piece joins the several columns at the base. By this modification a free passage is obtained from end to end for the condensed fluids, and the separate tar main is dispensed with.

Cleland's Slow-Speed Condenser.

This consists of a series of vertical pipes, connected together at the top by a hollow cornice or cap, which serves as the common inlet to the whole series. The stream of gas being thus divided equally amongst the several columns, travels through them in a downward direction and at a comparatively slow speed.

In the lower part of each column, to about a 5th part of its length, is inserted a "bottle brush" of wood or other material, with a drip ledge above it to divert the descending liquor on to the centre of the brush, which has the effect of converting the apparatus, to that extent, into a scrubber.

The general result is superior efficiency in condensing, and the yield of a high strength of liquor.

Atmospherical Horizontal Condenser.

The Atmospherical Horizontal Condenser (Fig. 30), is one of the earliest forms of the apparatus, and also the best. Its efficiency has not been generally recognized, owing to the want of a correct appreciation of the conditions on which the condensation of coal gas *ought to be conducted*, and this has led to its being generally discarded in *favour of the vertical form.*

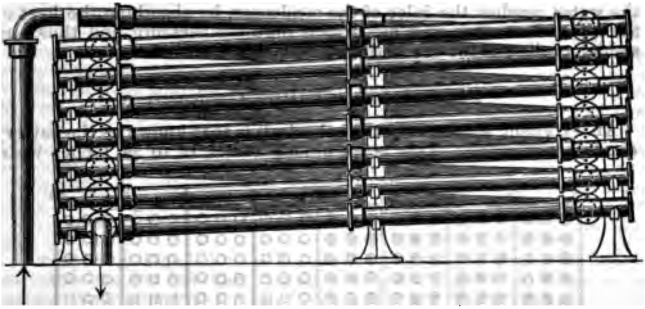


FIG. 30.

The earlier method of construction was to fix it against the outside of the wall of the retort house or other convenient building, the several pipes rising nearly parallel, one above the other, their ends being connected by ⊃-shaped bends.

An improvement, on strictly scientific principles, has been effected in the apparatus by Mr. D. A. Graham. A condenser designed by him consists of two series of 16-in. cast-iron pipes, 65 feet long, in ten of such 65 feet lengths, arranged in pairs side by side, and supported on framework, the end of each length being joined to that of the next. From the inlet at the top, through the entire run of the condenser to the outlet at the bottom, there is a gradual inclination, so that it is simply a flat screw or spiral, such as might be represented by winding a length of soft wire five times round a piece of board, in which case the two ends of the wire would answer to the inlet and outlet of the condenser. Blank flanges are bolted on the end of each length for convenience in cleansing.

In this arrangement there is a recognition of the fact that *length* rather than *height* is the desideratum in a condenser. In the ordinary vertical form of the apparatus, the cooling effect of the air on the surface of the upper parts of the pipes is almost *nil*. This will be obvious when it is considered that the air contiguous to the lower part of the condenser being assimilated to the temperature of the latter, expands, and so becoming lighter than the surrounding air, ascends in contact with the pipes, extracting a less and less proportion of heat as it rises.

In addition to the other advantages, the ammoniacal liquor on leaving the horizontal condenser is of a strength equal to 5° Twaddel —a result which it is impossible to obtain from the ordinary vertical form.

A somewhat similar form of condenser was previously designed and used by Mr. George Livesey.

Combined Atmospherical and Water Condenser.

Cutler's horizontal condenser has one or more small tubes passing through the interior of the larger pipes; through these tubes a stream of water flows in the opposite direction to the gas; so that by the time the water reaches the inlet of the condenser, by absorbing the heat the gas, it has attained a moderately high temperature, and thus an sudden cooling of the gas at the entrance is prevented.

The Tubular or Battery Condenser.

An excellent apparatus (atmospherical) is that known as the batter condenser (Fig. 31). This is an oblong vessel, 12 to 24 inches wid

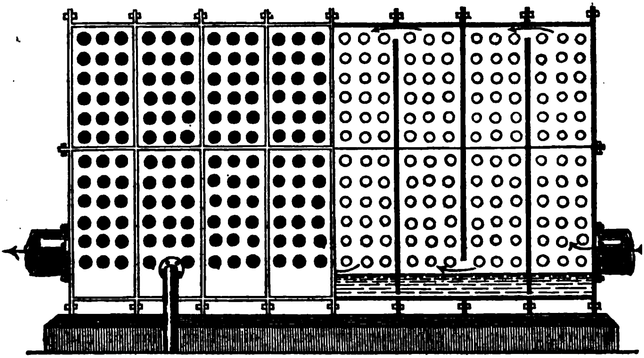


FIG. 31.

12 to 18 feet in height, and of length suitable to the requirements of th works. It is divided at distances, equal to the width, apart, by in ternal plates or mid-feathers, extending to within a few inches of th top and bottom of the chest alternately; and the gas passes from th inlet, up and down each division, till it arrives at the outlet. T augment its condensing power, small tubes, 2 inches in diamete through which the air has free circulation, are passed through fro side to side of the vessel, and there securely jointed. These transvers tubes serve the double purpose of cooling the gas, and, by breaking i up and retarding its progress, inducing a natural settlement of th heavy condensable vapours.

Rules for Calculating the Area required for Atmospherical Condensation.

It is stated in "Clegg" (4th edition, p. 173), that "the different stat in which crude gas enters the condensers make it impossible to giv any fixed rule for the determination of the area of the exposed surfac It may be dangerous even to venture on a general one; but it may b stated from experience that a surface of 150 square feet for every 100 cubic feet per hour is about sufficient when the stratum of gas has no exceeded 3 inches in thickness, and this without the application of water shower."

This is at the rate of 6¼ square feet of condensing surface for ever *1000 cubic feet maximum* production of gas per diem of 24 hours.

The superficial area of the original condensers designed by Mr. Croll for the Great Central Gas company was 4 feet per 1000 cubic feet maximum production per diem, or at the rate of 96 square feet for every 1000 cubic feet of gas produced per hour.

Another rule adopted by some gas managers is, to allow 10 square feet of condensing surface for the cooling of 1 cubic foot of gas per minute.

This gives at the rate of nearly 7 square feet of surface per 1000 feet per diem.

Others again insist that only 5 square feet of surface are needed for every 1000 feet made in 24 hours.

An average of the whole of the above gives rather over 5½ square feet.

Our opinion, founded on a lengthened experience, is that all these estimates are too low, and that about 10 superficial feet of condensing surface (atmospherical) for each 1000 cubic feet maximum production per day of 24 hours should be provided. This includes the length of main extending from the hydraulic main; moreover, the condenser should be protected from the direct action of the sun's rays, or otherwise water should be made to trickle down the outer surface of the pipes during sunshine.

Dry Scrubbers as Condensers.

In some works condensation is effected by means of dry scrubbers—cast-iron vessels of large diameter—charged with coke or other material, breaking up the gas into minute streams, which, being thus cooled, deposits its tar and water.

A natural settlement of the condensable matter also takes place, irrespective of the action of the contained material, owing to the velocity of the flow of the gas being reduced on entering the larger area.

The rapid fouling of these vessels, however, necessitating frequent changing of the material to prevent undue back pressure, and maintain their efficiency, renders their use objectionable.

Precipitating chambers of large size are also employed, without any filling material, in which the gas, as it were, sleeps, and deposits its condensable particles. A vessel of this kind is useful in other respects, because the large volume of gas serves as a cushion to counteract pulsatory action between the exhauster and the retorts.

Underground Condenser.

In this arrangement the pipes are placed in the ground, out of the reach of the fluctuations of temperature in the atmosphere, with a view to obtaining uniformity of action in the process of condensation. By this system, however, a much longer length of piping is required than by any other, owing to the small amount of radiation from the surface of the buried pipes.

There is an advantage in this process of gradual condensation, but it is advisable, wherever in use, to supplement it by finally passing the gas through one of the other forms of condensers made of less than the usual area.

Water-Channel Condenser.

Mr. Livesey, at the South Metropolitan Works, has adopted the plan of placing the condensing pipes in a tank divided into channels, through which a stream of water is made to flow, and, which can be regulated according to the make of gas. The water enters the tank at the point where the condensed gas makes its exit, and flowing in the opposite direction to the gas in the pipes, is gradually raised in temperature by the latter till it reaches its outlet, where the crude gas enters. By this means a more uniform condensation is obtained than is possible in the atmosphere.

Pelouze and Audouin's Condenser.

The principle of this is different to any of the other apparatus described. In construction it consists of an outer cylindrical cast-iron chamber, with the usual inlet for gas, and outlets for gas and liquids, and contains a cylinder of perforated sheet-iron constituting the condenser. The sides of the condensing chamber are two thin sheets of iron with a concentric space between. The inner sheet is perforated with holes 1-20th of an inch in diameter, and the outer with slots of larger size; the outer sheet being so arranged as to offer a blank surface opposite the small holes in the inner sheet. The gas and condensable vapours pass through the small perforations, the vapours being as it were wire-drawn, and striking against the opposite solid surface are deposited thereon, and flow down into the receptacle below, and thence to the tar well.

The gas passes on through the slots in the outer cylinder to the outlet pipe.

The condensing cylinder is so balanced as to rise and fall in an annular space containing tar or liquor which acts as a seal. As the make of gas increases or decreases, the cylinder rises or falls, and consequently a larger or less number of openings are uncovered for the passage of the gas. The result is a more complete separation of the tar from the gas than is attainable by any other form of condenser.

Carburetting Condensers.

The Aitken and Young Analyzer, and the St. John and Rockwell apparatus, may both be included under this head, as they are each designed by their inventors to enrich the gas by carburetion. The tar and gas are both conveyed direct from the hydraulic main to the apparatus, their temperature at the inlet being maintained as high as possible, and means are even adopted of raising the temperature, if required, in order that the heavier hydrocarbons present in the crude gas and tar may be permanently suspended, and so become fixed illuminants in the gas, notwithstanding the subsequent reduction of temperature in the ordinary course of purification. At the works where the respective processes have been adopted a good account is given of their efficiency.

TABLE

Exhibiting the Total Condensing Surface, Maximum Quantity of Gas Passing per Hour, and Condensing Surface per 1000 *Cubic Feet per Diem of 24 Hours, at the several London Works named.*

(Compiled from the Referees' Report on the Ammonia Impurity in Gas, June 1, 1871.)

Name of Company.	Chartered Company.						Imperial Company.			South Metropolitan Company.
Manufacturing Station.	Beckton.	Westminster.	Brick Lane.*	Curtain Road.*	Blackfriars.*	Bow Common.	Fulham.	St. Pancras.	Haggerston.	Old Kent Road.
Total condensing surface	† Sq. Ft. 32,342	Sq. Ft. 14,855	Sq. Ft. 7,744	Sq. Ft. 1,957	Sq. Ft. 13,470	Sq. Ft. 10,364	Sq. Ft.‡ 16,761	Sq. Ft. 26,258	Sq. Ft. 13,564	Sq. Ft.§ 14,666
Maximum quantity of gas passing per hour . . .	Cub. Ft. 125,000	Cub. Ft. 200,000	Cub. Ft. 95,000	Cub. Ft. 19,000	Cub. Ft. 125,000	Cub. Ft. 120,000	Cub. Ft. 350,000	Cub. Ft. 230,000	Cub. Ft. 250,000	Cub. Ft. 130,000
Condensing surface per 1000 cubic feet of gas produced per diem of 24 hours	Sp. Ft. 10·78	Sq. Ft. 3·1	Sq. Ft. 3·4	Sq. Ft. 4·3	Sq. Ft. 4·5	Sq. Ft. 3·6	Sq. Ft. 2·0	Sq. Ft. 4·75	Sq. Ft. 2·26	Sq. Ft. 4·7

The condensing surface, as given in the table, includes not merely the superficial area of the condensers proper, but also the whole length of pipes between the hydraulic main and the scrubbers.

* These works are now closed † Pipes placed in the ground.

‡ Including seven dry scrubbers used as condensers.

§ Pipes placed in a tank of water arranged in channels as before described.

In connexion with the subject of Condensation, the following Table, comparing the English and French Thermometers, will be found useful:—

Fahr.	Reau.	Cent.	Fahr.	Reau.	Cent.	Fahr.	Reau.	Cent.	Fahr.	Reau.	Cent.
212	80·0	100·0	153	53·7	67·2	95	28·0	35·0	37	2·2	2·7
211	79·5	99·4	152	53·3	66·6	94	27·5	34·4	36	1·7	2·2
210	79·1	98·8	151	52·8	66·1	93	27·1	33·8	35	1·3	1·6
209	78·6	98·3	150	52·4	65·5	92	26·6	33·3	34	0·8	1·1
208	78·2	97·7	149	52·0	65·0	91	26·2	32·7	33	0·4	0·5
207	77·7	97·2	148	51·5	64·4	90	25·7	32·2	32	0·0	0·0
206	77·3	96·6	147	51·1	63·8	89	25·3	31·6	31	− 0·4	− 0·5
205	76·8	96·1	146	50·6	63·3	88	24·8	31·1	30	− 0·8	− 1·1
204	76·4	95·5	145	50·2	62·7	87	24·4	30·5	29	− 1·3	− 1·6
203	76·0	95·0	144	49·7	62·2	86	24·0	30·0	28	− 1·7	− 2·2
202	75·5	94·4	143	49·3	61·6	85	23·5	29·4	27	− 2·2	− 2·7
201	75·1	93·8	142	48·8	61·1	84	23·1	28·8	26	− 2·6	− 3·3
200	74·6	93·3	141	48·4	60·5	83	22·6	28·3	25	− 3·1	− 3·8
199	74·2	92·7	140	48·0	60·0	82	22·2	27·7	24	− 3·5	− 4·4
198	73·7	92·2	139	47·5	59·4	81	21·7	27·2	23	− 4·0	− 5·0
197	73·3	91·6	138	47·1	58·8	80	21·3	26·6	22	− 4·4	− 5·5
196	72·8	91·1	137	46·6	58·3	79	20·8	26·1	21	− 4·8	− 6·1
195	72·4	90·5	136	46·2	57·7	78	20·4	25·5	20	− 5·3	− 6·6
194	72·0	90·0	135	45·7	57·2	77	20·0	25·0	19	− 5·7	− 7·2
193	71·5	89·4	134	45·3	56·6	76	19·5	24·4	18	− 6·2	− 7·7
192	71·1	88·8	133	44·8	56·1	75	19·1	23·8	17	− 6·6	− 8·3
191	70·6	88·3	132	44·4	55·5	74	18·6	23·3	16	− 7·1	− 8·8
190	70·2	87·7	131	44·0	55·0	73	18·2	22·7	15	− 7·5	− 9·4
189	69·7	87·2	130	43·5	54·4	72	17·7	22·2	14	− 8·0	−10·0
188	69·3	86·6	129	43·1	53·8	71	17·3	21·6	13	− 8·4	−10·5
187	68·8	86·1	128	42·6	53·3	70	16·8	21·1	12	− 8·8	−11·1
186	68·4	85·5	127	42·2	52·7	69	16·4	20·5	11	− 9·3	−11·6
185	68·0	85·0	126	41·7	52·2	68	16·0	20·0	10	− 9·7	−12·2
184	67·5	84·4	125	41·3	51·6	67	15·5	19·4	9	−10·2	−12·7
183	67·1	83·8	124	40·8	51·1	66	15·1	18·8	8	−10·6	−13·3
182	66·6	83·3	123	40·4	50·5	65	14·6	18·3	7	−11·1	−13·8
181	66·2	82·7	122	40·0	50·0	64	14·2	17·7	6	−11·5	−14·4
180	65·7	82·2	121	39·5	49·4	63	13·7	17·2	5	−12·0	−15·0
179	65·3	81·6	120	39·1	48·8	62	13·3	16·6	4	−12·4	−15·5
178	64·8	81·1	119	38·6	48·3	61	12·8	16·1	3	−12·8	−16·1
177	64·4	80·5	118	38·2	47·7	60	12·4	15·5	2	−13·3	−16·6
176	64·0	80·0	117	37·7	47·2	59	12·0	15·0	1	−13·7	−17·2
175	63·5	79·4	116	37·3	46·6	58	11·5	14·4	0	−14·2	−17·7
174	63·1	78·8	115	36·8	46·1	57	11·1	13·8	− 1	−14·6	−18·3
173	62·6	78·3	114	36·4	45·5	56	10·6	13·3	− 2	−15·1	−18·8
172	62·2	77·7	113	36·0	45·0	55	10·2	12·7	− 3	−15·5	−19·4
171	61·7	77·2	112	35·5	44·4	54	9·7	12·2	− 4	−16·0	−20·0
170	61·3	76·6	111	35·1	43·8	53	9·3	11·6	− 5	−16·4	−20·5
169	60·8	76·1	110	34·6	43·3	52	8·8	11·1	− 6	−16·8	−21·1
168	60·4	75·5	109	34·2	42·7	51	8·4	10·5	− 7	−17·3	−21·6
167	60·0	75·0	108	33·7	42·2	50	8·0	10·0	− 8	−17·7	−22·2
166	59·5	74·4	107	33·3	41·6	49	7·5	9·4	− 9	−18·2	−22·7
165	59·1	73·8	106	32·8	41·1	48	7·1	8·8	−10	−18·6	−23·3
164	58·6	73·3	105	32·4	40·5	47	6·6	8·3	−11	−19·1	−23·8
163	58·2	72·7	104	32·0	40·0	46	6·2	7·7	−12	−19·5	−24·4
162	57·7	72·2	103	31·5	39·4	45	5·7	7·2	−13	−20·0	−25·0
161	57·3	71·6	102	31·1	38·8	44	5·3	6·6	−14	−20·4	−25·5
160	56·8	71·1	101	30·6	38·3	43	4·8	6·1	−15	−20 8	−26·1
159	56·4	70·5	100	30·2	37·7	42	4·4	5·5	−16	−21·3	−26·6
158	56·0	70·0	99	29·7	37·2	41	4·0	5·0	−17	−21·7	−27·2
157	*55·5*	69·4	98	29·3	36·6	40	3·5	4·4	−18	−22·2	−27·7
156	*55·1*	*68·8*	97	28·8	36·1	39	3·1	3·8	−19	−22·6	−28·3
155	*54·6*	*68·3*	96	28·4	35·5	38	2·6	3·3	−20	−23·1	−28·8
154	*54·2*	*67·7*									

To convert Degrees of Fahrenheit into those of Centigrade and Reaumur, and conversely.

To convert Fahr. into Cent.

Rule 1st.—Subtract 32, and divide the remainder by 1·8, thus:—

$$\text{Fahr. } \frac{167 - 32}{1{\cdot}8} = 75 \text{ Cent.}$$

or by—

Rule 2nd.—Subtract 32, multiply the remainder by 5, and divide the product by 9, thus:—

$$\text{Fahr. } \frac{(167 - 32) \times 5}{9} = 75 \text{ Cent.}$$

To convert Cent. into Fahr.

Rule 1st.—Multiply by 1·8, and add 32, thus:—

$$\text{Cent. } 75 \times 1{\cdot}8 + 32 = 167 \text{ Fahr.}$$

or by—

Rule 2nd.—Multiply by 9, divide by 5, and add 32, thus:—

$$\text{Cent. } \frac{75 \times 9}{5} + 32 = 167 \text{ Fahr.}$$

To convert Fahr. into Reau.

Rule 1st.—Subtract 32, and divide by 2·25, thus:—

$$\text{Fahr. } \frac{113 - 32}{2{\cdot}25} = 36 \text{ Reau.}$$

or by—

Rule 2nd.—Subtract 32, multiply by 4, and divide by 9, thus:—

$$\text{Fahr. } \frac{(113 - 32) \times 4}{9} = 36 \text{ Reau.}$$

To convert Reau. into Fahr.

Rule 1st.—Multiply by 2·25, and add 32, thus:—

$$\text{Reau. } 36 \times 2{\cdot}25 + 32 = 113 \text{ Fahr.}$$

or by—

Rule 2nd.—Multiply by 9, divide by 4, and add 32, thus:—

$$\text{Reau. } \frac{36 \times 9}{4} + 32 = 113 \text{ Fahr.}$$

THE EXHAUSTER.

Wherever the make of gas exceeds 8 millions of cubic feet p annum, an exhauster becomes a useful adjunct to the other apparat of a gaswork; the invariable result of its use being to increase t

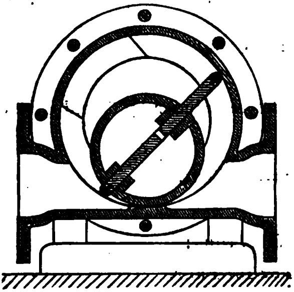


FIG. 32.

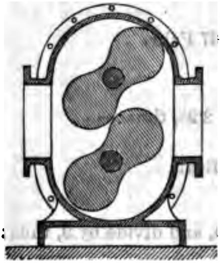


FIG. 33.

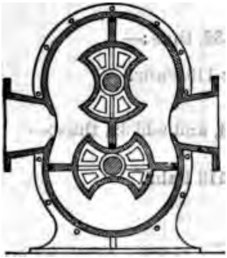


FIG. 34.

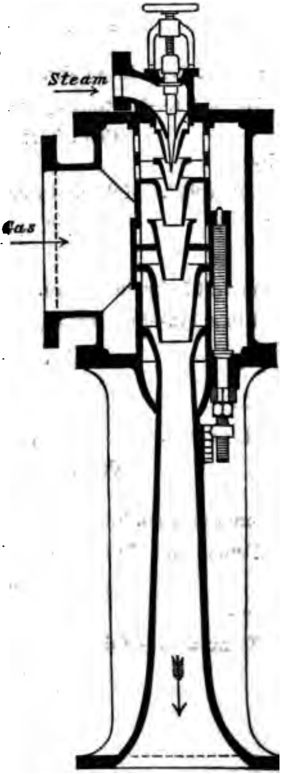


FIG. 35.

production per ton, to improve the quality of the gas (provided air is not drawn in) and lengthen the duration of the retorts, by preventing, in a great measure, the deposition of carbon, the removal of which with the ordinary chisel bars is so destructive and unsatisfactory.

Mechanical exhausters are of two kinds, the rotatory and the reciprocating. Both descriptions have their advocates, and much may be said in favour of each. The rotatory is certainly steadier in its action, producing less oscillation, the gas flowing more equably through the mains and apparatus.

Beale's (Fig. 32), Jones's (Fig. 33), and Laidlaw's (Fig. 34), are on the rotatory principle; Methven's, Musgrave's, and Anderson's (Fig. 36) are reciprocating.

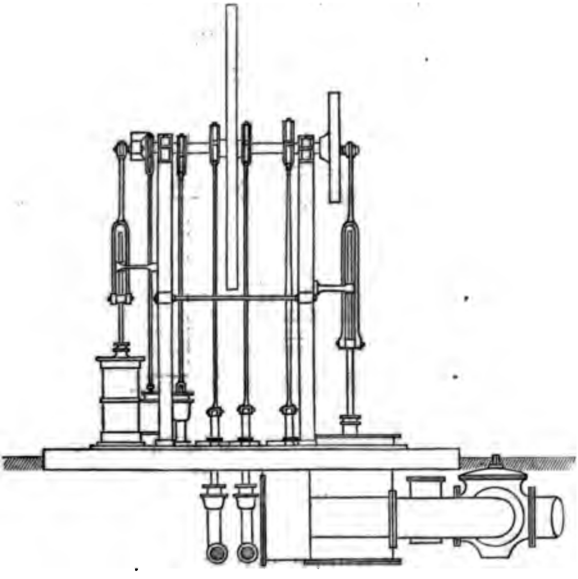


FIG. 36.

The steam-jet exhauster (Fig. 35), invented by Mr. Cleland, and improved by Messrs. Körting Brothers, is another form of exhausting apparatus. This operates by projecting a jet of steam at about 45 lbs. pressure, through an arrangement of pipes or nozzles, without the intervention of any other mechanical appliances—the steam being afterwards extracted by condensation. The capacity of the exhauster is regulated by the adjustable screw and spindle at the end; and by a movable inner sleeve, opening or closing the port holes by means of the screw and nut at the side.

Mr. R. O. Paterson found a gain in illuminating power equal to $\frac{2}{3}$ths of a candle from using this exhauster, which he attributed to the steam having volatilized some of the liquid hydrocarbons.

Exhauster Governor.

When an exhauster is employed, it is necessary to supplement its use by a gas governor, acting either on a throttle valve within the steam feed-pipe, in this case increasing or diminishing the speed of the engine; or on a valve within a bye-pass connected to the inlet and outlet mains leading to and from the exhauster, the opening of which, when the exhaust is too active, allows a portion of the gas to return through the exhauster, and thus prevents the formation of a partial vacuum in the retorts. (See Fig. 37.)

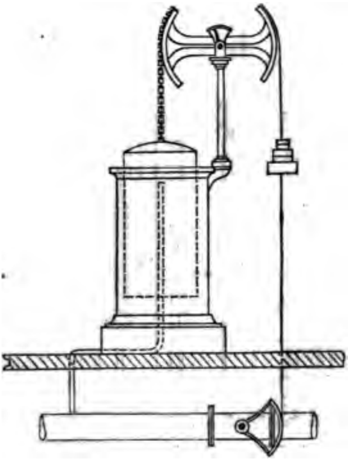


FIG. 37.

STEAM BOILER AND ENGINE.

These should be provided of ample size, allowing a margin over and above the actual power needed. An engine and boiler barely fit to do the work required of them are a nuisance.

The engine, besides turning the exhauster, may be used in pumping water and tar; and the boilers, in addition to supplying steam for the engine, is useful for steaming the mains and apparatus on the works.

Duplicate boilers of the required size should be provided, to allow for periodical cleaning and examination.

For firing the boiler, breeze may be used, mixed with a portion of coke or coal.

One pound weight of coal of average quality requires 150 cubic feet *of air for its perfect* combustion. In actual practice, however, about double this quantity of air passes through the furnace of steam boilers.

Wherever practicable and convenient, the boiler should be set in such a position as to allow of its being heated with the waste heat from the retort-stack.

In small works, if a steam boiler cannot be employed for want of space, or should a boiler be considered objectionable on other grounds, the exhauster can be driven by a gas engine.

The kind of boiler most suitable for a gas work of moderate size is the cylindrical, with flat ends, and single internal tube containing the furnace.

The nominal horse power of such a boiler is found by multiplying the sum of the diameters of the outer shell and internal flue by the length, and dividing the product by 6.

Example.—Required the power of a boiler whose diameter is 4 ft. 6 in., diameter of tube 2 ft. 6 in., and length 12 ft.

$$\frac{(4' \, 6'' + 2' \, 6'') \times 12'}{6} = 14 \text{ horse power.}$$

Again—

Required the power of a boiler whose diameter is 6 ft., diameter of tube 3 ft., and length 20 ft.

$$\frac{(6' + 3') \times 20'}{6} = 30 \text{ horse power.}$$

In high pressure or non-condensing engines, with—

Steam at 25 lbs. per square inch, 13·6 circular inches on piston = 1 horse power.
Do. 30 lbs. do. 11·3 do. = do.

The diameter of the piston in inches, squared = circular inches.

The following table gives the diameter of cylinders for high pressure (non-condensing) steam engines, from 3 to 16 horse power, with steam at 25 lbs. and 30 lbs. per square inch respectively, and the length of stroke for the different sizes—

Horse Power.	Diameter of Cylinder in Inches.		Length of Stroke.	Nominal Horse Power.	Diameter of Cylinder in Inches.		Length of Stroke.
	Steam per Square Inch.				Steam per Square inch.		
	25 lbs.	30 lbs.	Inches.		25 lbs.	30 lbs.	Inches.
3	6⅜	6	12	8	10⅜	9½	20
3½	6¾	6¼	12	8½	10¾	9⅞	20
4	7⅜	6¾	14	9	11⅛	10⅛	22
4½	7¾	7⅛	14	10	11¾	10¾	22
5	8¼	7½	16	11	12¼	11⅛	24
5½	8⅝	7⅞	16	12	12¾	11⅝	24
6	9	8¼	18	13	13¼	12¼	26
6½	9⅜	8⅝	18	14	13¾	12¾	26
7	9¾	9	18	15	14¼	13	28
7½	10⅛	9¼	20	16	15	13½	30

Cement for Stopping Leaks in Boilers.

	By weight.
Powdered fire-clay	6 parts.
Fine iron filings	1 part.

Made into a paste with boiled linseed oil.

Cement for Metallic Joints.

Equal weights of red and white lead, mixed with boiled linseed oil to the consistency of putty.

THE WASHER.

The washer was one of the very earliest appliances used in the purification of coal gas, and naturally so, owing to the cooling and condensing property of water, and its power of absorbing ammonia and of arresting the tar.

Its construction, however, was often faulty at first, and the limits of its functions misunderstood; so that the misuse, or overuse, of the apparatus, resulting in reduced illuminating power to the gas exposed to its action, caused it to fall for a time into disrepute.

The principle of its action is that of causing the gas to pass in finely-divided streams through a body of water contained in a vessel, so that a portion of the ammonia and other gaseous impurities, and the whole of the floating particles of tar which have escaped condensation, may be removed before the gas enters the scrubbers.

The washer should always be used in conjunction with the scrubber, and the gas passed through it in the first instance.

When the washer is exposed to atmospheric influence, it is necessary in winter to employ means to prevent the water from falling below a temperature of 50° Fahr.; otherwise the gas, especially a rich gas, passing through it will suffer deterioration.

The washer is generally employed as a separate and distinct apparatus, but sometimes it is placed at the bottom of the tower scrubber, of which it constitutes a part.

All washers give an amount of back pressure, varying from 1 to 4 inches, according to the depth of water traversed. There are numerous designs of washers, but the principal ones are here described.

Anderson's Washer.

The persistent advocacy of Mr. George Anderson has done much to restore the washer to favour, and his form of the apparatus is still one of the best.

It consists of a cast-iron outer vessel, containing a number of trays, having on their under side a series of serrated bars extending from side to side; these dip into the water or liquor, and the gas, in passing through the serrations is divided into minute globules. The pressure given can be regulated by raising or lowering the overflow with which the apparatus is provided. A four-way valve is used for shut-off and bye-pass. Weak liquor from the condenser is run in at the top, and drips from tray to tray till it reaches the bottom. The washer is made either single or double as required.

Cathels' Washer.

The usual oblong or square vessel in this case is divided into sections as many as may be desired, each elevated higher than the others in the form of steps. The gas enters at the bottom, passes in divided streams through a number of curtain serrations extending the full length of the vessel, and so on through the rest, and out at the top of the higher compartment. When the liquor in the lowest section is of the strength

:ed, it is run off, and the contents of the several sections trans- . one step lower, the last or uppermost being charged with fresh

s washer is also arranged in the vertical form to occupy less d space.

Livesey's Washer.

s is a compact and efficient apparatus, occupying less room for ork done than any other.

ı rectangular cast-iron box of any size (depending on the make of ı a series of rectangular tubes of wrought-iron, to which wrought- erforated plates are fastened, turned down at the sides till they ıto the liquor. The perforations are 1-20th of an inch diameter, 5th of an inch apart.

gas passes down between the tubes and through the side per- ons into spaces filled with liquor, and, bubbling upwards, is again n up by finding its way through the horizontal perforations into pen space above, and so along to the outlet of the apparatus. s are provided for securing an active circulation of the liquor ı is constantly flowing through it from the adjacent scrubber, and by an overflow to the well.

THE SCRUBBER.

tower scrubber (Fig. 38) is a cast-iron vessel, either rectangular or

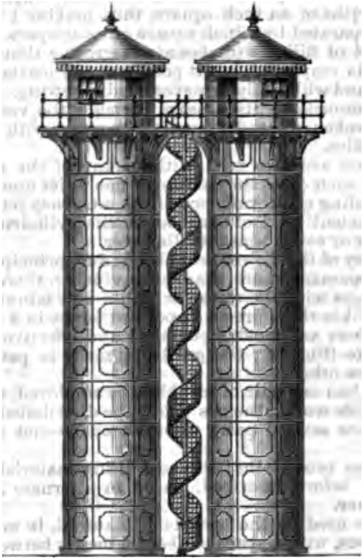


Fig. 38.

cylindrical (the latter shape being preferred), erected on end, through which the gas is made to pass in an upward direction after issuing from the washer.

Its primary use is to entirely purify the gas from ammonia by the aid of water, advantage being taken of the well-known great affinity of ammonia for that liquid.

Water, at mean temperature and pressure (60° Fahr., barometer 30), dissolves 783 times its volume of ammoniacal gas—that is, *undiluted* ammoniacal gas. When the latter is mixed with other gases, as in the case of coal gas, the power of water to arrest it is not nearly so great.

It also arrests a considerable proportion of the sulphuretted hydrogen and carbonic acid.

This is accomplished by filling the vessel wholly or in part with either coke, boulder-stones, brick-bats, roof or draining tiles, furze, or layers of thin boards set on edge, about 5 to 7 inches in width, ⅜ths of an inch thick, and from ½ to ¾ths of an inch apart; the material being kept constantly moistened by a stream of water trickling from a suitable distributing apparatus fixed in the crown.

When the coke or other material is placed in layers, it is supported on grids fixed at convenient distances apart; and opposite each space a manhole, secured by a movable lid or cover, is provided, so as to afford access to the interior, either for examination or renewal of the contained material.

The original Livesey scrubber is fitted with boards ¼th of an inch thick, 11 inches wide, placed on edge, and kept apart by strips or blocks of wood ¾ths of an inch square, thus making 1 board to 1 inch. The tiers are separated by 2-inch square cross sleepers.

The first cost of filling with boards is greater than when coke or other material is employed, but it possesses the marked advantage of not fouling up, and will rarely or never need renewing. The gas cannot form narrow channels in its passage through the vessel, but is constantly being broken up and brought in contact with the water that drips from all sides.

Open scrubbers are also used without any of the materials above mentioned. In such cases the column of gas in its upward progress is met by a descending shower of spray from a Gurney jet.

The most efficient kind of scrubber is the cylindrical, standing in height about six or seven times its diameter.

The superiority of the Tower Scrubber is due, principally, to the fact that in this apparatus, more than in any other, there is lengthened contact of the gas with the water or liquor in a minute state of subdivision. Height is therefore an important factor in a scrubber.

Tower Scrubbers are most economical and effective when they are used in duplicate (Fig. 38); the gas being made to pass through first one, and then the other.

Where more than one pair of scrubbers is employed, as is the case in many considerable works, the gas should be distributed in equal quantities through the several pairs simultaneously—not through each in succession.

Experience has proved that the best filling material is thin rough-sawn boards, as before described, placed in alternate layers, on edge, one over the other.

When coke is used as the scrubbing material, it may be placed in *six or* eight layers, with a space of about 6 inches between each.

Whatever material is used in filling the scrubber, it is important that all parts of its surface should be wetted as equally as possible. The proper action of the scrubber depends on this.

The necessity of a good water distributing apparatus is therefore apparent. Not only should this be of good construction in the first instance, but it should always be maintained in efficient working order.

The gas enters at the bottom of the vessel, and the water or liquor at the top. The gas in travelling upwards is completely broken up, fresh surfaces being constantly presented to the descending drip, and to the wetted sides of the filling material, against which it is rubbed or "scrubbed" all the way up, until it emerges by the outlet at the top. A trapped overflow at the bottom conveys the liquor either to the washer or to the tar well.

The gas, before entering the scrubbers, should have the whole of the tar eliminated from it; and to insure this, a washer may be employed. The washer can be conveniently placed at the bottom of the first scrubber.

The weak ammoniacal liquor from the hydraulic main and condenser, and from the second scrubber, should be employed in the first scrubber. The object of this is to arrest a proportion of the carbonic acid and sulphuretted hydrogen, as well as the other sulphur compounds, for which ammonia has a strong affinity, thus relieving the lime and oxide purifiers, and saving labour and purifying materials. The weak liquor is also by this means brought up to the requisite commercial strength.

Fresh water, in the proportion of two to three gallons per 1000 cubic feet of gas passing, is used in the second scrubber, to remove the last vestige of ammonia. It also takes up a considerable proportion of the deleterious gases above named.

One method frequently adopted of applying the water or liquor is by a pipe passing through the crown or side of the vessel, from which pipe smaller tubes, pierced with holes, radiate towards the circumference. This may be either fixed or revolving, the latter being the most efficient.

Mr. Mann, who has bestowed much attention to this subject, with most satisfactory results, makes the uppermost part of his scrubbers about 2 or 3 inches wider than the rest, in order that the sides of the vessel may be wetted as well as the contained material. In this wider portion of the scrubber, and underneath the distributing tubes, he has a revolving layer of birchwood twigs lessening in depth towards the circumference, and the water falling upon this is equally distributed throughout. This arrangement requires the use of a small engine and gearing to produce the slow rotary motion.

To obviate the necessity for an engine, a Barker's mill or other similar appliance is sometimes used for producing the required motion; but as the stream of water necessary to keep this in constant action would be too great for scrubbing purposes, the mill is usually fed intermittently from a tilting box, or a vessel holding several gallons of water, and fitted with a valve and float. Where the quantity of liquor passing is large, a small turbine may be adopted for turning the distributor.

Note.—The action of the Barker's Mill is due to the pressure of water being equal and acting in contrary directions. The rotary portion of the machine revolves about its vertical axis. This consists of a shaft or spindle working in suitable bearings, and passing through a cylinder open at the upper end, which is fed by a stream of water;

near to the bottom of this cylinder, horizontal radiating tubes are fixed, and on one side of these, holes are drilled for the outlet of the water. The pressure at these points being removed, acts only on the opposite side, so causing the mill to revolve, the velocity increasing with the height of the liquid and the size of the apertures.

Tower scrubbers should have an aggregate cubical volume of at least 9 feet for each 1000 cubic feet of gas made per day of 24 hours, taking the *maximum* production as the basis of the calculation. For example, take a works producing in the depth of winter 600,000 cubic feet of gas per day of 24 hours:—

Then,

600 × 9 = 5400 feet, cubical volume required.

This would be supplied by

2 scrubbers, each 8 ft. diameter, and 56 ft. high.

Or again, take a works producing 1,000,000 cubic feet per day:—

Then,

1000 × 9 = 9000 feet, cubical volume required.

This would be supplied by

2 scrubbers, each 10 ft. diameter, and 58 ft. high.

ANDERSON'S COMBINED WASHER AND SCRUBBER.

A combined washer and scrubber, the invention of Mr. George Anderson, consists of a rectangular cast-iron vessel, standing on end, and in height about five times its width. The vessel is divided into compartments, each of which contains a drum caused to revolve by suitable gearing. The circumference of each drum is fitted with a brush of whalebone or other fibre. These fit exactly into the space allotted for them, and, in revolving, dip into the liquid which partially fills the several divisions. The scrubber stands on one of Mr. Anderson's washers, previously described (p. 92). A small stream of pure water, at the rate of 10 to 12 gallons per ton of coal carbonized, is kept flowing into the top compartment through a funnel and sealing tube, and gradually descends by way of the gas-pipes connecting the chamber till it enters the washer, from which there is an overflow pipe to the well. The gas enters the washer at the bottom, and is first relieved of the tar remaining after condensation; thence it passes through the revolving brushes, meeting different strengths of liquor in each division, till it reaches the upper one containing pure water, and away by the outlet. By this means the whole of the ammonia, and a large proportion of the other impurities is removed.

THE SCRUBBER WASHER.

Another useful form of scrubber, or washer-scrubber, as it has been designated, of which Mr. Paddon's apparatus is the original type, has come largely into use in recent years. This is of the horizontal form, ectangular in sectional plan, and consists of a cast-iron tank or vessel, usually in sections, containing water or liquor, in which a series of erforated discs, or volutes of sheet-iron, or other filling medium exposng a large surface, are made to revolve on a central shaft, at a slow peed. These, as they rise from the liquid, are completely wetted on oth sides, and the crude gas passing through or amongst them, oming in contact with the wet surfaces, is deprived of its ammonia nd a portion of the other objectionable compounds. The clean or resh water entering at one end, and flowing through the different ivisions, is met by the gas which enters at the opposite end, and radually increases in strength till it issues from the final compartment s 10 or 12 ounce ammonaical (5° or 6° Twaddel) liquor. Kirkham, Iulett, and Chandler's "Standard" Washer-Scrubber, and Laycock nd Clapham's "Eclipse" Washer-Scrubber, are of this type.

TABLE

howing the Number of Volumes of Various Gases which 100 *Volumes of Water, at* 60° *Fahr. and* 30 *inches Barometric Pressure, can absorb.* (*Dr. Frankland.*)

Ammonia	7800 volumes.
Sulphurous acid	3300 ,,
Sulphuretted hydrogen	253 ,,
Carbonic acid	100 ,,
Olefiant gas	12·5 ,,
Illuminating hydrocarbons	Not determined, but probably more soluble than olefiant gas.
Oxygen	3·7 volumes.
Carbonic oxide	1·56 ,,
Nitrogen	1·56 ,,
Hydrogen	1·56 ,,
Light carburetted hydrogen	1·60 ,,

When water has been saturated with one gas and is exposed to the nfluence of a second, it usually allows a portion of the first to escape hilst it absorbs an equivalent quantity of the second. In this way a mall portion of a not easily soluble gas can expel a large volume of an asily soluble one.

BYE-PASS MAINS AND VALVES.

It is necessary that the condenser, exhauster, washer, scrubber, tation-meter, and governor, should be provided with bye-pass mains, losed with valves or water-traps, to allow of any of the apparatus eing put out of action for cleaning or repairs. The exhauster byeass is closed with a flap valve, so that in case of sudden stoppage of he machinery the valve opens by the pressure of the gas being thrown gainst it, and allows the gas to flow unchecked.

THE TAR WELL.

The tar well may be either built of bricks laid in cement, and carefully puddled at the bottom and sides, or formed of cast or wrought-iron plates, bolted together, and caulked with iron cement. The latter is preferable where the construction of a good foundation is likely to be a question of great expense.

It should be of capacity sufficient to contain six weeks' make of material, reckoning from the maximum daily production.

Another well of smaller dimensions, the size depending on the magnitude of the works, ought to be provided, to serve as a lute or seal, into which the tar-pipes from the different apparatus should dip. From this, at a depth of about 15 or 18 inches below the surface of the ground, an overflow-pipe or channel conveys the condensed products into the larger reservoir.

In some works the tar-pipe is taken direct into the large well, and there sealed by being made to dip into a vertical pipe secured to the bottom of the tank. This is objectionable, as, in case of stoppage, it is difficult of access.

In all cases the wells should be covered over to exclude rain water, and prevent the possible loss of ammonia by evaporation.

In addition to the underground tar-well, an elevated cast-iron cistern is indispensable in a well-appointed gas works. Into this the tar and liquor are pumped from the underground well, and suitable draw-off pipes, furnished with stop cocks or valves, serve to discharge the material into the barrels, trucks, or barges of the purchasing contractor.

The cistern may be divided in two by means of a partition plate reaching to within about 6 inches of the top, over which the ammoniacal liquor will flow, separating itself from the tar by reason of its lower specific gravity.

A tar and liquor separator, for placing in the ground in any convenient position near to the underground well, is shown in plan and sectional elevation in Figs. 39 and 40. It consists of a cast-iron vessel, about 4 feet square and 4½ feet deep (for a considerable sized gas works). The division plate extends from the top of the vessel to within 4 inches of the bottom; the diaphragm, over which the tar escapes into its separate well, being placed 1½ inches lower than the other diaphragm for the ammoniacal liquor.

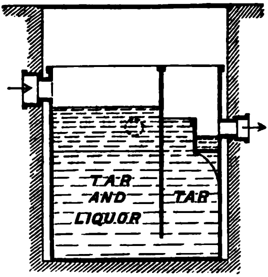


FIG. 39.—VERTICAL SECTION.

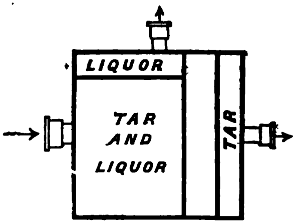


FIG. 40.—PLAN.

TABLE.

Contents of Circular Tanks or Wells, in Gallons for each Foot in Depth.

Diameter. Ft.	In.	Gallons for each Foot in Depth.	Diameter. Ft.	In.	Gallons for each Foot in Depth.	Diameter. Ft.	In.	Gallons for each Foot in Depth.
9	0	397·6	16	6	1336·4	24	0	2827·4
9	3	420·0	16	9	1377·2	24	3	2886·7
9	6	443·0	17	0	1418·6	24	6	2946·5
9	9	466·6	17	3	1460·7	24	9	3006·9
10	0	490·9	17	6	1503·3	25	0	3068·0
10	3	515·7	17	9	1546·6	25	3	3129·6
10	6	541·2	18	0	1590·4	25	6	3191·9
10	9	567·3	18	3	1634·9	25	9	3254·8
11	0	594·0	18	6	1680·0	26	0	3318·3
11	3	621·3	18	9	1725·7	26	3	3382·4
11	6	649·2	19	0	1772·1	26	6	3447·2
11	9	677·7	19	3	1819·0	26	9	3512·5
12	0	706·9	19	6	1866·6	27	0	3578·5
12	3	736·6	19	9	1914·7	27	3	3645·1
12	6	767·0	20	0	1963·5	27	6	3712·2
12	9	798·0	20	3	2012·9	27	9	3780·0
13	0	829·6	20	6	2062·9	28	0	3848·5
13	3	861·8	20	9	2113·5	28	3	3917·5
13	6	894·6	21	0	2164·8	28	6	3987·1
13	9	928·1	21	3	2216·6	28	9	4057·4
14	0	962·1	21	6	2269·1	29	0	4128·3
14	3	996·8	21	9	2322·1	29	3	4199·7
14	6	1032·1	22	0	2375·8	29	6	4271·8
14	9	1068·0	22	3	2430·1	29	9	4344·6
15	0	1104·5	22	6	2485·0	30	0	4417·9
15	3	1141·6	22	9	2540·6	30	3	4491·8
15	6	1179·3	23	0	2596·7	30	6	4566·4
15	9	1217·7	23	3	2653·5	30	9	4641·5
16	0	1256·6	23	6	2710·8	31	0	4717·3
16	3	1296·2	23	9	2768·8	31	3	4793·7

PURIFICATION.

The Impurities in Coal Gas.

The chief impurities present in coal gas, in its crude or raw state, at the time it leaves the retorts, are tar vapour, ammonia, carbonic acid, sulphuretted hydrogen, and other sulphur compounds, notably bisulphide of carbon.

The first-named impurity, tar vapour, begins to condense and is partially removed in the hydraulic main and pipes leading to the condensing apparatus, where, if this is of sufficient capacity, and otherwise adapted to the performance of the work required of it, it is nearly all removed; what remains of it is taken out by the washer.

The ammoniacal gas also begins to separate from the crude coal gas in the hydraulic main, combining with the moisture distilled from the coal. In the condenser and washer a further portion is removed, and in the scrubbers, if these are as efficient as they ought to be, or can easily be rendered, the whole of the remaining ammonia (amounting to about ·15 per cent.) is extracted.

The condensers, washers, and scrubbers are also efficacious in removing a portion of the carbonic acid (existing in the gas to the extent of about 2·5 per cent.), sulphuretted hydrogen (about ·8 per cent. of which is contained in the gas), and bisulphide of carbon; but the bulk of these three latter impurities still exists in the gas after leaving the scrubbers, and is carried forward to the purifiers.

These are charged either with hydrate of lime or hydrated peroxide of iron, or a combination of both substances, arranged in separate layers or tiers within the several vessels.

Purification by means of Lime (Oxide of Calcium).

The lime has a perfect and strong affinity for carbonic acid and sulphuretted hydrogen, and accordingly it entirely removes these compounds from the gas, without leaving the slightest trace of their presence. The lime, however, in its state of oxide of calcium, has no affinity for the bisulphide of carbon, so that the greater proportion of this impurity (all, except such part as is removed by the foul lime when in the state of sulphide of calcium), is carried forward into the holders.

Preparation of the Lime.

Cream or milk of lime was used in purifying in the early days of gas manufacture, and though this was thoroughly efficient, and is probably the most economical method of employing the lime, it has been generally discarded on account of the obnoxious character of the refuse material, "blue billy," as it was called, and the difficulty of getting rid of it. Lime in the hydrated state is now generally adopted.

The lime should be prepared by being slaked with clean water a day or two before it is required for use. If placed in the purifiers before this necessary interval has elapsed, it is liable to cake or become more compact than it otherwise would. On the other hand, hydrate of lime absorbs carbonic acid from the atmosphere, and its purifying power is nullified in proportion to the extent of such absorption. It should not, therefore, be prepared for any great length of time before it is needed.

It is a common mistake to place the prepared lime in the purifiers in a comparatively dry and almost powdery state. Lime used in this condition is less effective than when thoroughly moistened. It is also a wasteful method of using the lime, as a large proportion of the material will be found unspent, and almost untouched by the impurities, when the vessel requires to be changed. The finely divided lime is also more liable to cake than the other, and thus increase the back pressure. When the production of gas is great, as in the depth of winter, these disadvantages are strongly felt.

Mr. Forstall's instructions for preparing the lime are excellent. After it has been thoroughly well watered, "A simple and effective means of gauging the proper degree of moisture, and securing its uniformity throughout the whole charge of lime operated upon, is to pass the slaked lime through a wire screen, with an open mesh of one square inch area, placed at an angle of 70° with the floor. This screening reduces the lumps to granular pellets of irregular form and size, the largest not exceeding the bulk of a small hickory nut. The proper degree of moisture is that beyond which any excess will cause the 'dough' to adhere to the screen instead of breaking through. Slight variations of moisture in different portions of the charge are corrected by the thorough mingling of the whole in the screening. The pellets do not adhere to one another spontaneously, but can be shovelled into barrows, and reshovelled into the purifiers without losing their independence; but the slightest compression and working in the hand resolves them immediately into adhesive putty. The lime in this state is so penetrable to gas, that lumps as large as walnuts are thoroughly saturated, even when lying loosely upon the surface of the layers." The weight of the lime prepared in the manner described, and ready for the purifiers, is 92 lbs. to the bushel.

Quick lime nearly doubles in bulk on being slaked.

From 90 to 140 lbs. of quick lime, reduced to a hydrate, are required in the purification of the gas produced from 1 ton of cannel, and from 60 to 80 lbs. of that produced from 1 ton of coal.

Mr. Hislop has patented a process of calcination in suitable kilns by which the spent lime is converted into quick lime to an almost unlimited extent, and at considerably less cost than new lime. A nuisance is thus got rid of, and further economy in purification effected.

. . . .

Purification by means of Hydrated Peroxide of Iron.

Oxide of iron possesses the property of combining with the sulphuretted hydrogen, but it has no affinity for carbonic acid and bisulphide of carbon; hence when this oxide is used exclusively, the two latter named impurities are still present in the gas as supplied from the holders. This remark, however, needs some qualification. As oxide of iron, pure and simple, it has no affinity for bisulphide of carbon and other sulpho-carbon compounds, but from the observations made at the several metropolitan gas-works, Mr. R. H. Patterson (one of the Referees) deduced the interesting fact that the sulphur which is present in a minute state of division in the oxide of iron, after the latter has been in use for some time and frequently revivified, possesses the power of arresting a portion of the bisulphide of carbon.

The hydrated peroxide of iron may be either the natural oxide, bog iron ore, as it is called, found largely deposited in some of the bogs in Ireland and elsewhere; or the artificial oxide, obtained as a waste product from various processes of the manufacturing chemist.

Oxide of iron possesses this advantage over lime: After it has been in the purifier, and has taken up its *quantum* of sulphuretted hydrogen, it can be revivified on exposure to the air. Accordingly, when this material is used, a floor has to be provided on which it can be spread out, and turned over for revivification. At the Manchester Gas-Works, a horse and plough are employed for turning over the foul oxide.

When taken out of the purifier it is sulphide of iron, of a dense black; and after exposure it changes to its original reddish brown colour, oxygen having been taken up, and sulphur deposited in the free state in the mass. When the sulphur is found in it to the extent of about 56 per cent. by weight, the material is returned to the manufacturing chemist, and replaced by fresh oxide.

Mr. J. G. Hawkins has discovered that by drawing in a very small proportion of air at the inlet to the condenser, revivification *in situ* can be effected to a large extent. The purifiers are thus made to continue in use for a greater length of time without changing, whilst it is remarkable that the oxide by this process can be charged with as much as 75 per cent. of free sulphur. The illuminating power of the gas is not affected by the air, the oxygen of which enters into combination with the purifying material. Purifiers with a proportionately large area in comparison with the make of gas, are required to obtain the full advantage of this process.

In using fresh oxide of iron it is necessary to exercise certain precautions. The foul material, on its exposure to the air for the first two or three times, absorbs oxygen so rapidly as often to generate very intense heat, the whole mass frequently becoming red hot. Should this occur in the purifiers the danger is considerable, and the wood grids may be completely destroyed. Whenever, therefore, a purifier containing such new oxide has been put out of action, it should be *emptied without delay*, and the foul material spread out on the revivifying floor. The danger of ignition may be overcome by mixing the new oxide with a proportion of the spent.

Average Composition of the Richer Descriptions of Native Bog Ore for Purifying Purposes, dried at 212° Fahr. (*King's Treatise*) :—

Ferric oxide	60 to 70 per cent.
Organic matter	15 to 25 „
Silica.	4 to 6 „
Alumina.	1 „

As generally used, the material contains 30 to 40 per cent. of water.

Purification by means of Oxide of Calcium (lime), Sulphide of Calcium (foul or spent lime), and Oxide of Iron.

Lime alone, or the lime and oxide of iron, when properly applied, are capable of freeing the gas entirely of the whole three impurities, carbonic acid, sulphuretted hydrogen, and bisulphide of carbon. This brings us to the method of purifying expounded by the Referees in their report to the Board of Trade on Sulphur Purification at the Beckton Gas-Works, January 31st, 1872; and also by Dr. Odling, somewhat more in detail, in his lecture on Sulphide of Carbon, delivered at the Annual Meeting of the British Association of Gas Managers, held in London, in June, 1872.

To accomplish this perfect purification in accordance with the suggestions made by Dr. Odling, three sets of purifiers are required; the gas passing through the first set into the second, and on to the third, from which it makes its exit through the station-meter into the holders. The *modus operandi* is as follows :—

Let it be assumed that three sets of purifiers, consisting of four vessels each, are employed. Nine of these are constantly in action, three being at rest (one from each set), for the purpose of changing or revivifying the purifying material.

The first and second sets are charged with lime, the third set with oxide of iron.

Say the whole nine are newly charged. On the gas from the scrubbers entering the first set, the lime is acted on by the carbonic acid and sulphuretted hydrogen simultaneously, leaving the bisulphide of carbon at the beginning of the process to pass unabsorbed. After they have *worked for some time* the sulphuretted hydrogen in the first set is *gradually expelled by* the incoming carbonic acid, for which the lime has *a stronger affinity.* The second set is now being fouled with sulphuretted hydrogen, the lime being wholly or in part changed in character, having become sulphide of calcium, in which state it has an affinity for, and consequently arrests, the bisulphide of carbon and other sulpho-carbon compounds; whilst the unabsorbed sulphuretted hydrogen passes on to be finally taken up by the oxide of iron with which the final set of purifiers is charged. By the application of the proper tests at the several sets of purifiers, the time for changing the material is ascertained.

The question of supplying gas entirely free from sulphur in any form is a formidable one for gas companies; not so much because of the cost (though that is considerable) of erecting the additional sets of purifiers, as from the difficulty of providing the necessary ground space for their erection. In new works about to be constructed the thing is easily arranged; but in the majority of works already established it would not be easy to carry the system into effect.

As regards the question of cost, a careful estimate shows that to adopt the extended method of purifying as enunciated, would entail an outlay of additional capital equivalent to close upon 2d. per 1000 cubic feet of gas sold.

The property of absorbing or arresting bisulphide or disulphide of carbon possessed by the sulphide of calcium, was known by chemists and some observant managers of gas-works for a period considerably anterior to the date of the publication of either the able report of the Referees, or of the valuable lecture of Dr. Odling, and the principle of purification, therein recommended acted on to some extent. Dr. Letheby, in a paper communicated to the British Association of Gas Managers in 1870, speaking of the mode of purification pursued at the Great Central Works, and, after referring to the scrubbers, goes on to say, that "the gas is then passed through a series of dry lime purifiers, which present a very large surface for absorption; and the lime is purposely left in the purifiers after it has become foul, and until a good deal of the sulphuretted hydrogen first absorbed is displaced by carbonic acid. In this manner the natural affinity of sulphide of calcium for bisulphide of carbon is permitted to act, and much sulphur, in this objectionable form, is retained. Leaving the lime purifiers, the gas, which is still charged with more or less of sulphuretted hydrogen, is passed through oxide of iron. * * * * The chemical effect of these operations is very intelligible, for sulphide of ammonium (in the scrubbers, &c.) and sulphide of calcium are both endowed with the power of combining with bisulphide of carbon, and therefore of absorbing and fixing this objectionable impurity. It is manifestly then, of the greatest importance that coal gas should be kept in contact with these substances as long as possible during the process of purification. * * * In the case of sulphide of calcium, it should be permitted to act for some time after the lime has become foul, for it is in this condition that it is most effective, and a lime purifier should not be changed until the sulphuretted hydrogen of the foul lime is largely displaced by the carbonic acid of the raw gas. If it be necessary to use oxide of iron, on account of the difficulty of disposing of foul lime, it should be used after the lime."

It remained, however, for Mr. R. H. Patterson to show, which he did conclusively, that this complete purification could only be successfully attained by first extracting the carbonic acid, as, until that was entirely removed from the crude gas, it was impossible to obtain the sulphide of calcium in sufficient quantity or condition to arrest the bisulphide of carbon.

Purification by means of Caustic Soda and Sulphide of Sodium.

Mr. Patterson has patented a process of purifying by washing or scrubbing the gas in solutions of caustic soda and sulphide of sodium, extracting the carbonic acid and sulphur impurities, and so dispensing altogether with the ordinary lime and oxide of iron purifiers. The soda solutions, when saturated with the impurities, possess the important quality of being easily and perpetually revivified or restored to their original state on the gas works, whilst the whole of the sulphur is secured for sale. The plan, however, has not been tried on an adequately large scale.

Purification by means of Caustic Ammonia, and Carbonate of Ammonia.

Attempts have been made by Mr. Laming, Mr. Livesey, Mr. F. C. Hills and others, to purify the gas in closed vessels by employing the ammonia found in the gas, for arresting the other impurities. Unfortunately, the loss of ammonia at each time of desulphurating the liquor, owing to its extreme volatility, has hitherto prevented success in this direction.

CLASSIFICATION

Of the best known Limestones of this Country, in the Order of their Purity, and which Order also expresses their Value for the purpose of Purifying Coal Gas. (*Hughes.*)

1. The white chalk limestone of Merstham, Dorking, Charlton, Erith, and other parts of the chalk range surrounding the metropolis.
2. The grey chalk limestone, from the lower beds of chalk.
3. The blue beds of the upper and middle Oolites.
4. The lower white and grey limestones of the Oolites.
5. The most calcareous and crystalline beds of the carboniferous or mountain limestone, colours grey and bluish.
6. The magnesian limestone of Yorkshire and Derbyshire.
7. The white lias limestone.
8. The blue lias limestone.
9. The Silurian limestone of Wenlock, Dudley, &c., and the coralline limestones of Plymouth and the neighbourhood.

The value of limestone as a purifying agent is in inverse proportion to the amount of earthy or foreign matter it contains; that which leaves the smallest proportion of insoluble sediment on being dissolved in diluted acid is the best.

Limestone is the carbonate of lime found in its natural state, from which the oxide of calcium (quick or caustic lime) is produced by the expulsion of the carbonic acid by means of heat in the limekiln.

Quick or Caustic Lime (oxide of calcium) is lime in the solid state, before absorbing, or being slaked with, water.

Hydrate of Lime is lime in a moist state. It is a chemical compound of lime and water in the proportion of one part of water to three parts of lime.

Milk of Lime, or Cream of Lime, is a mixture or solution of hydrate of lime and water.

WEIGHT AND MEASUREMENT OF LIME.

1 bushel of quicklime weighs about	70 lbs.	
1 cubic foot of „ „	54 „	
1 „ yard of „ „	1460 „	
1 ton of „	is equal to about 32 bushels.	

TABLE

owing the Composition of the Different Limestones and their Specific Gravity. (Government Commission.)

Quality of Limestone and Locality.	Carbonate of Lime.	Carbonate of Magnesia	Silica. (Flint.)	Iron Alumina. (Clay.)	Water and Loss.	Specific Gravity. (Dry.)
ɪcaster, Lincolnshire . .	93·59	2·90	..	·80	2·71	2·182
ɪth Box, Wiltshire . . .	94·52	2·50	..	1·20	1·78	1·889
ɪrtland, Dorsetshire . .	95·16	1·20	1·20	·50	1·94	2·145
ɪtton, Rutlandshire . .	92·17	4·10	..	·90	2·83	2·045
ɪrnack, Northamptonshire	93·40	3·80	..	1·30	1·50	2·090
ɪilmark, Wiltshire . . .	79·00	3·70	10·40	2·00	4·20	2·481
ɪm Hill, Somersetshire .	79·30	5·20	4·70	8·30	2·50	2·260
A trace of bitumen was observed in each of the above.						
ɪlsover, Derbyshire . .	51·10	40·20	3·60	1·80	3·30	2·316
ɪddlestone, Yorkshire . .	54·19	41·37	2·53	·80	1·61	2·147
ɪche Abbey do. . .	57·50	39·40	·80	·70	1·60	2·134
ɪrk Nook do. . .	55·70	41·60	..	·40	2·30	2·138

PURIFYING HOUSE.

house to contain the purifiers should be lofty and well venti- not only for the comfort of the workmen employed therein, but en or entirely remove the risk of explosion from any leakage of at might occur. The house should also be arranged with a view ɪre extension.

a convenient plan to build the house with a ground and upper ɪnd to place the purifying vessels on the latter, with the con- ns and centre valve underneath and fully exposed and accessible. round floor can thus be used for revivifying the oxide of iron, if ɪaterial is employed, or for other purposes.

vessels are discharged through an opening in the bottom of each, by a gastight lid, and the fresh material is raised by means of lless ladder, or other suitable elevating apparatus, to the floor

PURIFIERS.

Construction and Arrangement of the Purifiers.

purifying vessels are almost invariably made of cast-iron, with ron covers secured with suitable fastenings, to prevent their being ɪy the incoming gas pressing on their under surface.

Malam's arrangement of four in the set, with connections and centre valve (Fig. 41), by which three of the vessels are kept in actio and one out of use for renewal of the purifying material, is still generall adopted, and is the simplest and most convenient. In some works

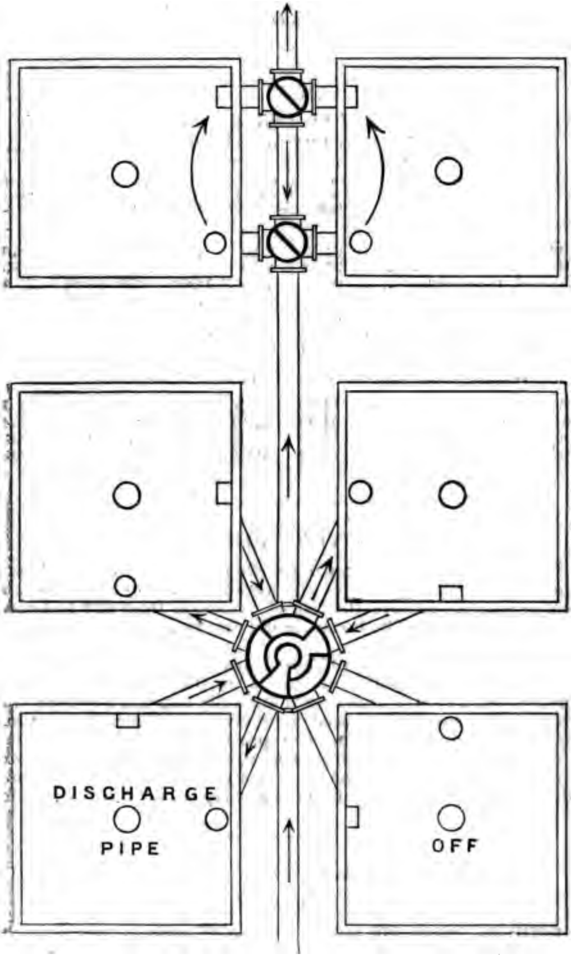


Fig. 41

second set of two purifiers is used in addition to the series of four, and these are connected together, and to the others, with single or four-way valves. (Fig. 41.) Under this arrangement the set of four are charged with oxide to arrest the sulphuretted hydrogen, and the set of two with lime to take up the carbonic acid, the gas passing through them in the order shown.

Depth and best Form of Purifiers.

In determining the size of purifiers, where either dry lime or oxide of iron is intended to be used, it is of the utmost importance to provide a liberal superficial area, and to make ample allowance for increased gas-make.

One of the greatest sources of discomfort to a gas manager is having his purifiers so cramped and confined in their area as to be incapable of doing the work required in an efficient manner.

The ordinary and best form of purifier is the square or oblong; this shape is the cheapest, affords the largest area for the space occupied, and is also the most convenient as regards the placing of the trays or grids.

The usual depth of purifiers is 5 feet; in some large gas-works they are 6 feet deep.

The capacity or purifying power of the vessel is determined more by its superficial area than its cubical volume. There is, however, a mutual relation between the two, as, when the depth is increased and fully utilized, the surface area has to be proportionately augmented, on account of the resistance offered by the deeper material to the flow of the gas. It is more strictly correct, then, to say that the superficial area, in proportion to the depth of the purifying material, is the gauge of the capacity or purifying power of the vessels; and the maximum hourly or daily gas-make of which the works are capable should form the basis of any calculation to determine their size.

Rules for Determining the Size of Purifiers.

It is stated in Clegg (4th ed., p. 200), that "the usual calculation with gas-makers in France is, that an area of about 1 foot is required for every 250 lbs. of coal carbonized in 24 hours, each purifier being supposed to contain three sieves, which would amount to about three square yards of surface to each ton of coal carbonized." This is not very explicit.

The same also states "that for every 150 cubic feet of gas per hour which can be generated, each purifier should present one superficial foot of surface." This allowance is absurdly small, and in practice, with anything near the maximum production, would be found altogether inadequate.

The rule given in Hughes (3rd ed., p. 158) is much to be preferred—viz., "Allow one superficial yard of sieve for every 1000 cubic feet of gas produced per diem."

Adopting this rule, a works capable of producing a maximum of 220,000 cubic feet of gas per day of 24 hours will require four purifiers, each 10 feet square, and having five tiers of lime sieves each.

Another rule, agreeing closely with the above, is to allow 10 square yards of sieve for every ton of coal and cannel that can be carbonized in 24 hours.

I venture on another rule which experience has taught me to regard with more favour than any of the above—viz., that where there is intended to be four purifiers, three always in action, the maximum daily (24 hours) make of gas, expressed in thousands, multiplied by the constant ·6, *will give the superficial area in feet of each purifier.*

Example.—Required the superficial area of each of the four purifiers in a works equal to the production of 500,000 cubic feet of gas per diem of 24 hours.

$$500 \times {\cdot}6 = 300 \text{ feet superficial area of each purifier.}$$

$$\sqrt{300} = 17{\cdot}3 \text{ (say, 18) feet side of square of purifier.}$$

For very small works where there is no exhauster, the constant ·8 may be employed with advantage.

Water Lute for Covers and Hydraulic Centre-Valve.

The evils of contracted area in purifiers are aggravated by having a shallow seal to the lids or covers and the hydraulic centre-valve.

In small works the water lute should never be less than 12 inches deep by 4½ inches wide; and in medium sized and large works, from 18 to 24 inches by 6 to 8 in width.

Ample depth of water lute is especially important where the back pressure is increased by the use of telescopic holders.

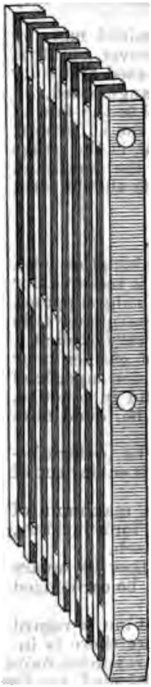


Fig. 42.

Number of Layers of Purifying Material.

In purifiers charged with hydrate of lime, there may be two or four tiers of sieves. The lime spread upon their surface may be from 4 to 8 inches in depth.

When oxide of iron is used, the layers may be two in number, and the material 18 or 24 inches deep on each.

Sieves, Trays, or Grids for Lime and Oxide of Iron.

Round wrought-iron rods, ⅜ of an inch thick, bound together with a framing of angle or flat-iron, make an excellent tray, especially where lime is used; they are less suitable for oxide of iron, which destroys them by corrosion, though when made of the strength named, they last for many years. They possess a great advantage over most other trays in the smaller space which they occupy in the purifier, and the larger purifying area obtained by their use. Perforated cast-iron and wood trays are suitable for either lime or oxide. The latter are usually made with strips of wood (yellow pine, pitch pine, or red deal, the prices being as 3, 2, 1) of any convenient length; the strips are 1⅞ inch broad, ½ an inch thick, and slightly tapered, the outer pieces or frame being of harder timber (hickory, beech, or ash), and 1¼ inches thick; the whole bound together with ⅜-inch bolts and nuts, having the heads, washers and nuts countersunk in the side frames, and the holes plugged with cement. The strips are kept ½ an inch to 5-8ths of an inch apart by pieces of wood of that thickness, and 1⅞ inches square, put between them at the places where the bolts are inserted (Fig. 42.)

Apparatus for Raising the Lids or Covers.

For raising the lids or covers of the purifiers, various contrivances are employed, the most common being a double purchase crab, travelling on iron rails laid on either wooden beams, or iron lattice girders, having their ends inserted in the walls of the building; or, in the absence of walls, supported on pillars.

The lifting machine, sometimes called a "Goliath," first constructed by Messrs. Cockey and Sons, is a useful and compact contrivance for the same purpose. This consists of two standards, one on each side of the purifier, connected across the top by two girders a few inches apart. The standards, having grooved or flanged wheels, or rollers attached, traverse the purifying house from one end to the other on rails laid on the floor. The covers are raised by means of two long vertical screws, with an eyelet-hole at the end of each, in which the hooks on the lid are inserted, and moved by a winch and cog-wheels put in motion by means of a handle at one of the sides. When the apparatus is not in use it can be wheeled out of the way, leaving the space above the purifiers to the tie-rods or beams of the roof entirely unobstructed.

Mr. Reid employs a somewhat similar travelling carriage; but, instead of the wheel gearing and screws, he uses hydrostatic pressure for accomplishing the same object. A full description, with drawing of his ingenious apparatus, was submitted by him to the North British Association of Gas Managers, at their meeting in July, 1872, and appears at length in the *Journal of Gas Lighting* for Aug. 27 of the same year.

Centre and other Change Valves.

The dry centre valve, with surface faced to fit gas-tight, is now extensively adopted, and, as a rule, is preferred to the old hydraulic centre-valve. The chief advantages it possesses over the latter are the greater ease and facility in changing from one purifier to another, one man being able to accomplish this with a few turns of a handle, thus minimizing to the utmost extent the passage of unpurified gas during that operation. It occupies less space, is entirely beneath the purifying-house floor, and presents a dead resistance to pressure, admitting of greater steadiness in the flow of the gas where an exhauster is at work.

Four-way valves are adopted by some managers in preference to the centre-valve, their chief recommendation being that by their use the connexions are simplified. The advantages which they possess over the ordinary single valve are more apparent. When the latter are employed, 12 are needed for a set of four purifiers, and six for a set of two; whereas, with the four-way valves, only one-third that number is required.

Size of Connecting-Pipes.

With respect to the size of the connecting-pipes, the rule is to make their internal diameter, *in inches*, equal, as nearly as possible, to the square root, *in feet*, of the area of the purifiers.

Thus, purifiers 10 feet square, giving an area of 100 square feet, have connecting-pipes 10 inches in diameter; and purifiers 16 feet by 12 feet, having an area of 192 square feet, have their connecting-pipes 14 inches in diameter. With the larger proportionate sizes of purifiers now being employed over those formerly erected, a deduction of ⅛ may safely be made from the result obtained by the above rule. Thu rule on pp. 107-8), a works capable of producing 500,000 cubic feet per day requires four purifiers, having each an area of 300 squa [500 × ·6 = 300], the square root being 17·3; deducting ⅛, or 2 have 15·1, or, say 15 inches, the diameter of connecting-pipes.

DRORY'S MAIN THERMOMETER.

The illustrations (Figs. 43 to 45) show the improved arrang

FIG. 43.

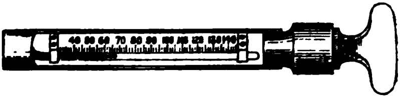


FIG. 44.

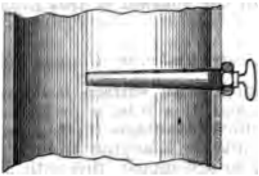


FIG. 45.

invented by Mr. Drory, for ascertaining the temperature of th passing through the condenser and other apparatus, and the n It consists of an outer shell fitted with a conical hollow plug havi aperture corresponding to that in the outer shell. The tester fits into the plug contains a thermometer, which on being t opposite to the apertures is in immediate contact with the gas, a withdrawal the temperature is ascertained. For attaching the t a hole suitable for a 1-inch wrought-iron pipe is drilled and t in the pipe or side of the apparatus, and the instrument is sc therein.

TESTS

For the Detection of Impurities in Coal Gas after the Ordin Processes of Purification.

Ammonia.

Expose yellow turmeric paper slightly moistened with wat *litmus paper first* reddened by any weak acid, to a jet of unli gas for about a minute. If the yellow colour of the turmeric be urned to brown, or if the blue of the litmus be restored, ammonia is present.

Turmeric and litmus papers may be purchased at the chemists, or hey can be prepared as follows:—

> **Turmeric Paper.**—Six parts by weight of spirits of wine are added to one of turmeric powder in a stoppered bottle, and well shaken up occasionally for three days. A portion of the clear fluid is then poured on a plate, and pieces of unsized white (filtering) paper well soaked therein. These are then dried in air, cut into strips half an inch wide and 2 inches long, and kept for use in a bottle away from the light.
>
> **Litmus Paper.**—Six parts by weight of water to one of powdered litmus, shaken well together, allowed to stand for several days, and then filtered. Pieces of white filtering paper are then thoroughly soaked in the solution, dried, and cut into strips, which should be kept in a close stoppered bottle, excluded as much as possible from the air and light. Should it be desired to redden the solution, add (after filtration) a small quantity of very dilute sulphuric acid, gradually, drop by drop, until the pink or neutral tinge is obtained.

Carbonic Acid.

Make a solution of pure barytes, and pass the gas through it. If carbonic acid be present, carbonate of barytes will be precipitated; or pass the gas through clear lime water, and carbonate of lime will be precipitated.

It may also be detected by adding to water impregnated with the gas a few drops of sulphuric acid, when minute bubbles of carbonic acid gas will be rapidly disengaged.

> **Lime Water** is prepared by agitating slaked lime with distilled water in a bottle or other vessel. It is then allowed to stand until the excess of lime has been deposited, when the clear liquid is poured off, and filtered through filtering paper.

Sulphuretted Hydrogen.

Moisten a piece of writing-paper with a solution of acetate of lead n distilled water, and expose it for not less than a minute to a jet of unlighted gas. If sulphuretted hydrogen be present, the paper will be browned or blackened.

A solution of nitrate of silver is a more delicate test than the above. This requires to be kept in a bottle coated outside with tinfoil, and placed in a drawer or other dark place to protect it from the influence f the light.

> **Lead Paper** may be made of white filtering paper soaked in the acetate of lead solution, then dried, cut into slips, and kept in a well-corked bottle for use. But the solution applied to the paper at the time of making the test is preferable.

The following are the regulations given in Schedule A of the Works Clauses Act, 1871, in respect of the apparatus and mo testing for sulpheretted hydrogen :—

Apparatus for Testing the presence in the Gas of Sulphu Hydrogen.—A glass vessel containing a strip of bibulous moistened with a solution of acetate of lead, containing sixty of crystallized acetate of lead dissolved in one fluid ounce of wat

Mode of Testing for Sulphuretted Hydrogen.—The gas sh passed through the glass vessel containing the strip of bibulous moistened with the solution of the acetate of lead for a period of minutes, or such longer period as may be prescribed; and if an coloration of the test paper is found to have taken place, this is held conclusive as to the presence of sulphuretted hydrogen i gas.

Sulphur.

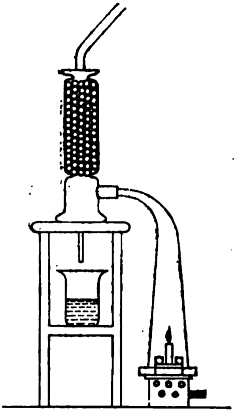


FIG. 46.

The sulphur present in gas, due to pounds other than sulphuretted hyd notably bisulphide of carbon, is esti by burning a jet of the gas at the rat cubic foot, or half a cubic foot, per for 24 hours, from a Leslie or other b arranged within the wide end of a tr tube, whose upper and smaller end serted in a condenser, from the opposi of which a tube carries off the uncond vapour, and creates a current throug apparatus. (See Fig. 46.) Through the and wide end, where the burner is fi supply of air, to support combustion, e carrying with it the vapour of am from liquid ammonia or pieces of th bonate contained in a suitable rece surrounding the burner. The am combining with the sulphurous acid the gas flame, is deposited within the denser as sulphite and sulphate of am from which the quantity of sulphur p cubic feet of gas is calculated.

Illuminating Power and Impurities.

The illuminating power of gas may be high, and at the same a good deal of sulphur and other impurities may be present. Pur not always in a given ratio with illuminating power.

Harcourt's Colour Test.

This is one of the most useful apparatus in the gas man laboratory for determining with ease and celerity the amount of phide of carbon, sulphuretted hydrogen, and carbonic acid in gas. *The following is a description of the test, and direction its use.*

Testing for Bisulphide of Carbon.

The arrangement of the colour test is shown in Fig. 47, the fire-clay cylinder being represented by dotted lines.

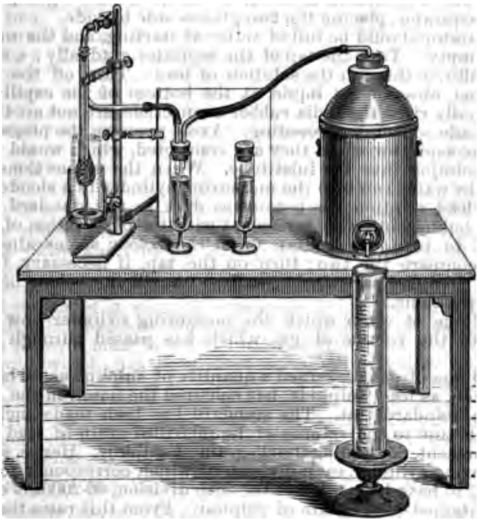


Fig. 47.

The bulb, which is filled with platinized pumice, is to be so adjusted that it may be about an inch above the burner, and in the middle of the cylinder.

To use the apparatus, turn on first the upper stopcock, sending gas through the bulb at the rate of about half a cubic foot an hour, as may be judged by lighting the gas for a moment at the end of the horizontal arm, when a flame about an inch in length should be produced. Raise the cylinder, which will be supported by the pressure of the wires, light the burner, and turn down the flame till it forms a blue non-luminous ring. Lower the cylinder, and place the small clay pieces upon it round the neck of the bulb.

A testing may be made five minutes after the burner is lighted, xcept when the apparatus is first used, when the gas should be allowed o flow through the bulb for a quarter of an hour, or a little longer, nd any number of testings one after another as long as the heat is ontinued.

The mode of testing is as follows:—Lay a piece of white paper on he table by the side of the burner, and fix a piece of cardboard upright n the brass clip; the cardboard serves as a background against which o observe the colour of the contents of the glasses, and should receive side light, and be as *clear* as possible from shadows. Fill one glass (once for all) up to the mark with standard coloured liquid, and cork it tightly. Dilute some of the lead syrup with twenty times its volume of distilled water, and fill the other glass up to the mark with a portion of the liquid thus prepared. Insert the caoutchouc plug with capillary-tube and elbow-tube, and connect, as shown in the figure, with the bulb and aspirator, placing the two glasses side by side.

The aspirator should be full of water at starting, and the measuring cylinder empty. Turn the tap of the aspirator gradually; a stream of bubbles will rise through the solution of lead. Turn off the tap for a minute, and observe the liquid at the bottom of the capillary-tube. If it gradually rises, the india-rubber connections are not air-tight, and must be made so before proceeding. Avoid pressing the plugs into the glass or the aspirator while they are connected, which would drive up the lead solution into the inlet-tube. When the connections are air-tight, let the water run into the measuring cylinder in a slender stream until the lead solution has become as dark as the standard. As the ascending bubbles interfere somewhat with the observation of the tint, it is best to turn off the tap when the colour seems almost deep enough; compare the two; turn on the tap, if necessary, for a few moments, then compare again; and so on, till the colour of the two liquids is the same.

The volume of water which the measuring cylinder now contains is equal to the volume of gas which has passed through the lead solution.

This volume of gas contained a quantity of sulphur as carbon bisulphide which, as lead sulphide, has coloured the liquid in the test-glass up to the standard tint. The standard has been made such that to impart this tint to the volume of liquid 0·0187 grain of lead sulphide must be present, containing 0·0025 grain of sulphur. Hence, supposing the measuring cylinder, each division of which corresponds to 1-2000th cubic foot, to have been filled to the 30th division, 30-2000ths cubic foot of gas contained 0·0025 grain of sulphur. From this ratio the number of grains of sulphur existing as bisulphide in 100 cubic feet of the sample of gas tested can easily be calculated.

The following table gives the relation between (V) the divisions of the measuring cylinder filled with water, and (S) the grains of sulphur existing as bisulphide in 100 cubic feet of gas. Since gas contains besides carbon bisulphide, some other sulphur compounds which are not transformed into sulphuretted hydrogen by the action of heat, and which contain sulphur amounting ordinarily to 7 or 8 grains in 100 cubic feet, this quantity must be added to that found by the test, if it is wished to know approximately the total amount of sulphur in the gas.

Table I.

$$S = \frac{500}{V}$$

V	S	V	S	V	S	V	S
10	50·0	18	27·8	26	19·2	34	14·7
11	45·4	19	26·3	27	18·5	35	14·3
12	41·7	20	25·0	28	17·9	36	13·9
13	38·5	21	23·8	29	17·2	37	13·5
14	35·7	22	22·7	30	16·7	38	13·2
15	33·3	23	21·7	31	16·1	39	12·8
16	*31·3*	24	20·8	32	15·6	40	12·5
17	*29·4*	25	20·0	33	15·1	41	12·2

S	V	S	V	S	V	S
11·9	57	8·8	72	6·9	87	5·7
11·6	58	8·6	73	6·9	88	5·7
11·4	59	8·5	74	6·8	89	5·6
11·1	60	8·3	75	6·7	90	5·6
10·9	61	8·2	76	6·6	91	5·5
10·6	62	8·1	77	6·5	92	5·4
10·4	63	7·9	78	6·4	93	5·4
10·2	64	7·8	79	6·3	94	5·3
10·0	65	7·7	80	6·2	95	5·3
9·8	66	7·6	81	6·2	96	5·2
9·6	67	7·5	82	6·1	97	5·2
9·4	68	7·4	83	6·0	98	5·1
9·2	69	7·2	84	6·0	99	5·1
9·1	70	7·1	85	5·9	100	5·0
8·9	71	7·0	86	5·8	150	3·3

›r the next testing, the test-glass is to be disconnected and ıarged. The water in the measuring cylinder is poured back into aspirator.

ıe colour of the standard is unaffected by exposure to light, but ›ens if the liquid is warmed, returning to its original shade as the ıd cools. If, therefore, the glass containing the standard has been warm place, it must be let cool before testing.

ıe liquid which has been used becomes colourless after being ›sed to the light for a few hours, and may thus be used over and again for 20 times or more, if it is not allowed to absorb carbonic from the air. The best mode of working is to have two well- ed flasks, into one of which the coloured liquid is emptied while glass is re-charged from the other.

Testing for Sulphuretted Hydrogen and Carbonic Acid.

ıe apparatus may also be used without the bulb-tube and stand to the amount of sulphuretted hydrogen or carbonic acid in gas at any e in its purification.

ıe gas is led in this case directly into the test-glass, which is gəd with lead solution for sulphuretted hydrogen, and with a rated solution of barium hydrate (baryta water) for carbonic

hen the gas contains more than 50 grains of sulphur as sulphu- ›d hydrogen in 100 cubic feet, a smaller cylinder, containing)th cubic foot, is used to measure the volume of liquid run from the rator. The divisions on the smaller cylinder are tenths of the cor- onding divisions on the larger cylinder; therefore when it is used numbers under S in Table I. must be read as whole numbers by ;ting the decimal points.

› estimate carbonic acid a standard liquid containing a definite unt of suspended barium carbonate is used for comparison. The ses are placed side by side on a blackened board or piece of paper with a black background behind them. The passage of the gas ıld be interrupted, and the test-glass slightly shaken once or twice to ı down any particles of carbonate which may cling to the sides of glass above the surface of the liquid. The standard should also be en before the comparison is made, in order that the precipitates be in a similar condition. When the two liquids are judged to be lly white and opaque, the volume of water in the measuring ıder gives the volume of gas which has precipitated a known weight of barium carbonate. Table II. gives the relation between (V) the divisions of the large measuring cylinder filled with water, and (C) the volume of carbonic acid in 100 volumes of gas. When the gas contains more than ·72 per cent. of carbonic acid, the smaller measuring cylinder should be used, and the values of (C) multiplied by moving the decimal point one place to the right.

TABLE II.

V	C	V	C	V	C	V	C
10	·72	33	·22	56	·13	79	·09
11	·65	34	·21	57	·13	80	.09
12	·60	35	·21	58	·12	81	·09
13	·55	36	·20	59	·12	82	·09
14	·51	37	·20	60	·12	83	·09
15	·48	38	·19	61	·12	84	·09
16	·45	39	·18	62	·11	85	·08
17	·42	40	·18	63	·11	86	·08
18	·40	41	·17	64	·11	87	·08
19	·38	42	·17	65	·11	88	·08
20	·36	43	·17	66	·11	89	·08
21	·34	44	·16	67	·11	90	·08
22	·33	45	·16	68	·11	91	·08
23	·31	46	·16	69	·10	92	·08
24	·30	47	·15	70	·10	93	·08
25	·29	48	·15	71	·10	94	·08
26	·28	49	·15	72	·10	95	·08
27	·27	50	·14	73	·10	96	·07
28	·26	51	·14	74	·10	97	·07
29	·25	52	·14	75	·10	98	·07
30	·24	53	·14	76	·09	99	·07
31	·23	54	·13	77	·09	100	·07
32	·22	55	·13	78	·09	150	·05

After each testing the glass and capillary-tube should be cleaned with a little dilute hydrochloric acid and well rinsed with distilled water. The turbid liquid is poured into a flask, which should be kept well corked, containing an excess of crystallized barium hydrate. After the suspended precipitate has subsided, the clear liquid is poured off, or, if necessary filtered, into another flask, also kept well corked, from which it may be poured into the test-glass when required. Care should be taken not to expose the solution to the air longer than necessary.

Instructions of the London Gas Referees as to the Times and Mode of Testing for Purity.

The testings for purity shall extend over twenty hours of each day, and shall be made upon ten cubic feet of gas, which shall be tested successively for each of the following impurities:

I.—*Sulphuretted Hydrogen.*

The gas shall be passed as it leaves the service pipe through an apparatus in which are suspended slips of bibulous paper, impregnated with basic acetate of lead.

The test-paper from which these slips are cut is to be prepared from time to time by moistening sheets of bibulous paper with a solution of one part of sugar of lead in eight or nine parts of water, and holding each sheet while still damp over the surface of a strong solution of ammonia for a few moments. As the paper dries all free ammonia escapes.

If any discolouration of the slip of test-paper is found to have taken place, this is to be held conclusive as to the presence of sulphuretted hydrogen in the gas. Fresh test-slips are to be placed in the apparatus every day.

In the event of any impurity being discovered, one of the test-slips shall be placed in a stoppered bottle and kept in the dark at the testing-place; the remaining slips shall be forwarded with the daily report.

II.—*Ammonia.*

The gas which has been tested for sulphuretted hydrogen shall pass next through an apparatus consisting of a glass cylinder filled with glass beads, which have been moistened with a measured quantity of standard sulphuric acid. A set of burettes, properly graduated, is provided.

The maximum amount of ammonia allowed is 4 grains per 100 cubic feet of gas; and the testings shall be made so as to show the exact amount of ammonia in the gas.

Two test-solutions are to be used—one consisting of dilute sulphuric acid of such strength that 25 measures (septems) will neutralize 1 grain of ammonia; the other a weak solution of ammonia, 100 measures (septems) of which contain 1 grain of ammonia.

The correctness of the result to be obtained depends upon the fulfilment of two conditions:—

1. The preparation of test-solutions having the proper strength.
2. The accurate performance of the operation of testing.

To prepare the test-solutions the following processes may be used by the Gas Examiner:—

Measure a gallon of distilled water into a clean earthenware jar, or other suitable vessel. Add to this 94 septems of pure concentrated sulphuric acid, and mix thoroughly. Take exactly 50 septems of the liquid and precipitate it with barium chloride in the manner prescribed for the sulphur test. The weight of barium sulphate which 50 septems of the test-acid should yield is 13·8 grains. The weight obtained with the dilute acid prepared as above will be somewhat greater, unless the sulphuric acid used had a specific gravity below 1·84.

Add now to the diluted acid a measured quantity of water, which is to be found by subtracting 13·8 from the weight of barium sulphate obtained in the experiment, and multiplying the difference by 726. The resulting number is the number of septems of water to be added.

If these operations have been accurately performed, a second precipitation and weighing of the barium sulphate obtainable from 50 septems of the test-acid will give nearly the correct number of 13·8 grains. If the weight exceeds 13·9 grains, or falls below 13·7 grains, more water or sulphuric acid must be added, and fresh trials made, until the weight falls within these limits. The test-acid thus prepared should be transferred at once to stoppered bottles, which have been well drained and are duly labelled.

To prepare the standard solution of ammonia, measure out as before a gallon of distilled water, and mix with it 50 septems of strong solution of ammonia (sp. gr. 0·88). Try whether 100 septems of the test-alkali thus prepared will neutralize 25 of the test-acid, proceeding according to the directions given subsequently as to the mode of testing. If the acid is just neutralized by the last few drops, the test-alkali is of the required strength. But if not, small additional quantities of water, or of strong ammonia solution, must be added, and fresh trials made, until the proper strength has been attained. The bottles in which the solution is stored should be filled nearly full and well stoppered.

The mode of testing is as follows:—Take 50 septems of the test-acid (which is greatly in excess of any quantity of ammonia likely to be found in the gas,) and pour it into the glass cylinder, so as to well wet the whole interior surface, and also the glass beads. Connect one terminal tube of the cylinder with the gas supply, and the other with the meter, and make the gas pass at the rate of about half a cubic foot per hour. Any ammonia that is in the gas will be arrested by the sulphuric acid, and a portion of the acid (varying with the quantity of ammonia in the gas) will be neutralized thereby. At the end of each period of testing, wash out the glass cylinder and its contents with distilled water, and collect the washings in a glass vessel. Transfer one-half of this liquid to a separate glass vessel, and add a quantity of a neutral solution of hæmatoxylin or litmus just sufficient to colour the liquid. Then pour into the burette 100 septems of the test-alkali, and gradually drop this solution into the measured quantity of the washings collected, stirring constantly. As soon as the colour changes (indicating that the whole of the sulphuric acid has been neutralized), read off the quantity of liquid remaining in the burette. To find the number of grains of ammonia in 100 cubic feet of the gas, multiply by 2 the number of septems of test alkali remaining in the burette, and move the decimal point one place to the left.

The remaining half of the liquid is to be preserved for a week in a bottle duly labelled.

III.—*Sulphur Compounds other than Sulphuretted Hydrogen.*

The gas which has been tested for sulphuretted hydrogen and ammonia shall pass next through a meter by means of which the rate of flow can be adjusted to half a cubic foot per hour, and which is provided with a self-acting movement for shutting off the gas when ten cubic feet have passed.

The testing shall be made in a room where no gas is burnt other than that which is being tested for sulphur and ammonia.

The apparatus to be employed is represented by the diagram, (Fig. 46), and is of the following description:—The gas is burnt in a small Bunsen burner with steatite top, which is mounted on a short cylindrical stand, perforated with holes for the admission of air, and having on its upper surface a deep circular channel to receive the wide end of a glass trumpet-tube. On the top of the stand, between the narrow stem of the burner and the surrounding glass trumpet-tube, are to be placed pieces of commercial sesqui-carbonate of ammonia weighing in all about 2 ounces.

The products both of the combustion of the gas and of the gradual volatilization of the ammonia salt go upwards through the trumpet-tube into a vertical glass cylinder, packed with balls of glass, to break up the current and promote condensation. From the top of the cylinder there proceeds a long glass pipe or chimney, serving to effect some further condensation, as well as to regulate the draught and afford an exit for the uncondensable gases. In the bottom of the cylinder is fixed a small glass tube, through which the liquid (formed during the testing) drops into a beaker placed beneath.

The following cautions are to be observed in selecting and setting up the apparatus:—

> See that the inlet-pipe fits gas-tight into the burner, and that the holes in the circular stand are clear. If the burner gives a luminous flame, remove the top piece, and having hammered down gently the nozzle of soft metal, perforate it afresh, making as small a hole as will give passage to half a cubic foot of gas per hour at a convenient pressure.
>
> See that the tubulure of the condenser has an internal diameter of not less than ¾ inch, and that its outside is smooth and of the same size as the small end of the trumpet-tube.
>
> See that the short piece of india rubber pipe fits tightly both to the trumpet-tube and to the tubulure of the condenser.
>
> The small tube at the bottom of the condenser should have its lower end contracted, so that when in use it may be closed by a drop of water.
>
> The india-rubber pipe at the lower end of the chimney-tube should fit into, and not simply rest upon, the mouth of the condenser, and the upper extremity of this tube may with advantage be given a downward curvature.

At the end of each period of testing, the cylinder and trumpet-tube are to be well washed out with distilled water. Fresh pieces of sesquicarbonate of ammonia are to be used each day.

The gas examiner shall then proceed as follows:—

The liquid in the beaker and the water used in washing out the apparatus shall be put into the same vessel, well mixed, and measured. One-half of the liquid so obtained is to be set aside, and preserved for a week, properly labelled, in case it should be desirable to verify the correctness of the testing.

The remaining half of the liquid is to be put into a flask, or beaker covered with a large watch-glass—treated with hydrochloric acid sufficient in quantity to leave an excess of acid in the solution—and then raised to the boiling point. An excess of a solution of barium chloride is now to be added, and the boiling continued for five minutes. The vessel and its contents are to be allowed to stand till the barium sulphate settles at the bottom of the vessel, after which the clear liquid is to be as far as possible poured off through a paper filter. The remaining liquid and barium sulphate are then to be poured on to the filter, and the latter well washed with hot distilled water. (In order to ascertain whether every trace of barium chloride and ammonium chloride has been removed, a small quantity of the washings from the filter should be placed in a test tube, and a drop of a solution of silver nitrate added; should the liquid, instead of remaining perfectly clear, become cloudy, the washing must be continued until on repeating the test no cloudiness is produced.) Dry the filter with its contents, and transfer it into a weighed platinum crucible. Heat the crucible over a lamp, increasing the temperature gradually, from the point at which the paper begins to char, up to bright redness. When no black particles remain, allow the crucible to cool; place it when nearly cold in a desiccator over strong sulphuric acid, and again weigh it. The difference between the first and second weighings of the crucible will give the number of grains of barium sulphate. Multiply this number by 11 and divide by 4; the result is the number of grains of sulphur in 100 cubic feet of the gas.

This number is to be corrected for the variations of temperature and atmospheric pressure in the manner indicated under the head of Illuminating Power (see *post*), with this difference, that the readings of the barometer and thermometer are to be taken for the day on which the testing commenced and also the day on which it closed; and the mean of the two is to be used.

This correction may be made most simply and with sufficient accuracy in the following manner:—

When the tabular number is between 955-965, 966-975, 976-985, 986-995; increase the number of grains of sulphur by $\frac{4}{100}$ths, $\frac{3}{100}$ths, $\frac{2}{100}$ths, $\frac{1}{100}$th.

When the tabular number is between 996-1005, no correction need be made.

When the tabular number is between 1006-1015, 1016-1025, 1026-1035; diminish the number of grains of sulphur by $\frac{1}{100}$th, $\frac{2}{100}$ths, $\frac{3}{100}$ths.

Example: Barometer (mean). . . . . 29·4
Thermometer (mean) 58
Tabular number 985

Grains of barium sulphate from 5 cubic ft. of gas . . . . . 4·3
Multiply by 11, and divide by 4. 11

4) 47·3

Grains of sulphur in 100 cub. ft. of gas (uncorrected) . . . . . 11·82
Add 11·8 × $\frac{2}{100}$ = ... ·24

Grains of sulphur in 100 cub. ft. of gas (corrected) . . . . . 12·06
[Result: 12·1 grains.]

As to the maximum amounts of impurity in each form with which the gas shall be allowed to be charged.

Sulphuretted Hydrogen.

By the Acts of Parliament all gas supplied must be wholly free from this impurity.

Ammonia.

The maximum amount of this impurity shall be 4 grains per 100 cubic feet.

Sulphur Compounds other than Sulphuretted Hydrogen.

The maximum amount of sulphur with which gas shall be allowed to be charged shall be 22 grains of sulphur in every 100 cubic feet of gas.

STATION METER HOUSE.

The station meter house, if conveniently situated on the works, and made sufficiently large, may contain in addition to the meters, the station governors, exhaust, and pressure register, a range of pressure gauges, and a jet photometer.

When thus arranged they are all within the purview, and immediately under the control, of the workman in charge.

The meter house is susceptible of ornamentation, and should have a *little bestowed upon* it, besides being kept scrupulously clean and well *ventilated.*

Station Meter.

The quantity of gas manufactured, as it passes into the holders, after its purification has been completed, is measured and recorded by he station meter.

This is invariably of the "wet" description: that is to say, the measuring wheel is caused to revolve by the elastic force of the gas pressing upon the surface of a body of water, with which the vessel is charged up to a certain line.

In construction it differs slightly from the wet meters used by consumers, but its principle of action is identical with these.

The meter case, which is of cast-iron, is made either cylindrical Fig. 48), or rectangular (Fig. 49); the former shape being generally adopted for sizes up to 20,000 cubic feet per hour. When it is rectangular in form, the roof is composed of wrought-iron plates, usually No. 10 BWG.

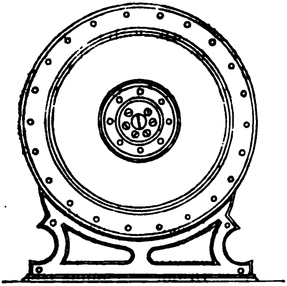


Fig. 48.

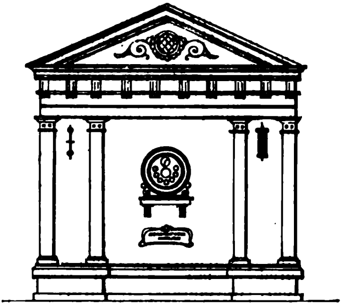


Fig. 49.

The measuring wheel or drum is made of charcoal annealed tinned plates, rivetted and soldered together in segments, and the shaft or axle is supported by anti-friction wheels.

The registering mechanism consists of a series of enamelled dials, with wheel-work and pointers indicating from 100 to 100,000,000 cubic eet at each of their revolutions. The dial figures, unlike those on the consumers' meters, all run in the same direction.

An eight-day clock and tell-tale apparatus are placed in front, above he index. On a circular plate, a disc of card paper, graduated, is ixed; and a lead pencil attached to a rod, which again is attached to and is actuated by the minute finger of the clock, pressing upon the paper, indicates the uniformity or otherwise of the gas production during each hour of the day and night.

The size or capacity of a station meter is designated by the quantity of gas in cubic feet which it is capable of passing per hour, the measuring wheel making 120 down to 70 revolutions, as a maximum, in hat time (the number of revolutions depending on the size of the nstrument) with a loss of pressure not exceeding 5-10ths of an inch between the inlet and outlet. Thus, if the drum have a capacity of 50 cubic feet, 50 × 120 = 6000 cubic feet, the size of the meter. If the capacity be 200 cubic feet, then 200 × 100 = 20,000 cubic feet, the size of meter, and so on.

It is thus easy to determine the capacity of the wheel or drum required to measure any given production. Say the *maximum* hourly make of gas in a works is 30,000 cubic feet; then,

$$\frac{30{,}000}{100} = 300 \text{ cubic feet,}$$

the required capacity of the measuring wheel or drum.

In all cases a reasonable margin in size should be allowed for growing production.

When a meter wheel is driven beyond the speed above named, the friction is increased, more pressure is absorbed in working the wheel, and the registration is falsified.

The station meter should be placed perfectly level on a substantial foundation, with raised stone base.

It should be fitted with bye-pass and hydraulic trap, with outlet cock; shut-off valves; adjustable overflow pipe; water-line gauge; an ordinary pressure gauge each for the inlet and outlet pipes, and a differential pressure gauge; a thermometer; a filling tube and funnel, with stop cock, and a flushing cock.

TABLE.

Station Meter Details.

Quantity Measured per Hour.	Capacity per Revolution.	Number of Revolutions of Measuring Drum per Hour.	Pressure Absorbed in Actuating the Meter.	Diameter of Measuring Drum.		Depth or Length of Measuring Drum, minus Hollow Cover.	
Cubic feet.	Cubic feet.		Inch.	Ft.	In.	Ft.	In.
600	5	120	$\frac{3}{10}$	2	6	1	3¾
900	7·5	120	$\frac{3}{10}$	2	10½	1	8¾
1,200	10	120	$\frac{3}{10}$	3	0½	2	0½
1,500	12·5	120	$\frac{3}{10}$	3	5½	2	0½
1,800	15	120	$\frac{3}{10}$	3	5½	2	5
2,400	20	120	$\frac{3}{10}$	3	6½	2	10
3,000	25	120	$\frac{3}{10}$	4	0	3	0
3,600	30	120	$\frac{3}{10}$	4	0	3	5
4,800	40	120	$\frac{3}{10}$	4	3	4	2
6,000	50	120	$\frac{3}{10}$	4	7½	4	4½
7,200	60	120	$\frac{4}{10}$	4	11	4	6½
9,600	80	120	$\frac{4}{10}$	5	6	4	11
12,000	100	120	$\frac{4}{10}$	5	8	5	6½
15,000	150	100	$\frac{4}{10}$	6	8	6	8
20,000	200	100	$\frac{4}{10}$	8	0	6	3
25,000	250	100	$\frac{4}{10}$	8	0	7	0
30,000	300	100	$\frac{4}{10}$	8	1½	8	1
40,000	400	100	$\frac{4}{10}$	9	6	8	5
50,000	500	100	$\frac{4}{10}$	10	3	9	3
60,000	750	80	$\frac{4}{10}$	11	6	10	2
80,000	1,000	80	$\frac{4}{10}$	12	10	11	7
100,000	*1,430*	70	$\frac{4}{10}$	15	4	12	6

THE PRESSURE GAUGE.

The ordinary pressure gauge (Figs. 50 and 51) has its tubes, which are of glass, charged with water to the zero line on the ivory or boxwood scale between. This is graduated into inches and tenths. It is made of any length as required, and the scale may be figured either in inches or tenths of an inch, as shown.

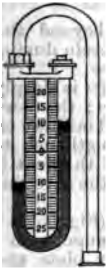


Fig. 50.

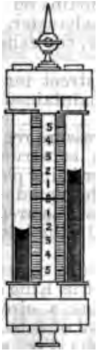


Fig. 51.

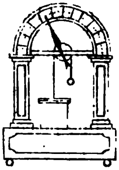


Fig. 52.

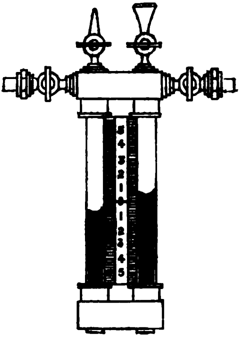


Fig. 53.

On being attached to the main, either directly or by means of a short connecting pipe, the difference between the two water levels represents the pressure therein.

A series of these gauges, to indicate the pressure between the different apparatus of the gas works, should be fixed in some position convenient for frequent inspection.

King's gauge (Fig. 52) is constructed on the same principle, but it indicates slighter variations of pressure; the finger having a long sweep for small differences of water level, and the dial being graduated into finer divisions.

The differential gauge (Fig. 53) is commonly attached to the inlet and outlet pipes respectively, of station meters; the indications of the instrument being the difference in pressure between the two, showing the pressure absorbed in actuating the meter.

Coloured water for pressure gauges is made by infusing a little pounded cochineal in hot water. It is then filtered, and a few drops of nitric or hydrochloric acid added, to prevent the bright scarlet colour from fading.

The glass tubes of pressure gauges, when foul, may be cleansed with a weak solution of sulphuric acid in water.

PRESSURE AND EXHAUST REGISTERS.

The principle of action of these instruments (Fig. 54) (invented by Crosley) is the same as that of the foregoing, but they are made to *record* as well as *indicate* the pressure or exhaust, as the case may be.

This is accomplished by means of a float in water, to which a vertical spindle is attached, having a lead pencil at the upper end, pressing upon a cylindrical graduated roll of paper upon a drum, which is caused to revolve by clockwork once in the 24 hours. The paper roll is renewed daily.

The exhaust register is connected to the mains on the works, at a point between the hydraulic main and the exhauster, and the record shows whether, in the absence of the manager, the exhauster has been kept working with regularity.

The pressure register is attached to the street main beyond the governor, and records the various pressures maintained therein during the day and night.

The difference between the exhaust and pressure registers is simply one of detail in construction; the zero line in the former being placed midway on the scale, and the spindle lengthened to correspond, whilst the area of the float is also increased. In the latter the zero line is at the bottom.

Wright's pressure register (Fig. 55) is a combination of the King's gauge, with a time-piece, having a circular plate and paper disc, instead of a dial. The 24 hours are printed on the disc, and a pencil at the end of a rod actuated by the float, pressing upon this, records the varying pressures.

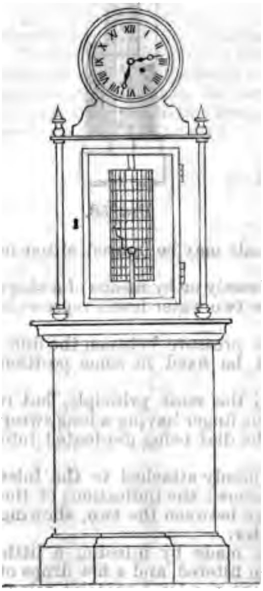


Fig. 54.

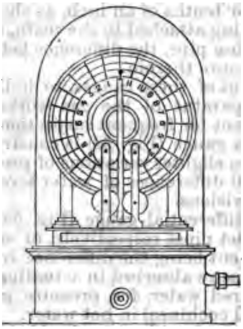


Fig. 55.

GASHOLDER TANKS.

The tank is that portion of the storage reservoir for gas which contains the water in which the floating vessel or holder rises and descends. (Fig. 56.)

It may be constructed either wholly or partially under the ground level, or (as in the case of iron tanks) entirely above ground. (Fig. 57.)

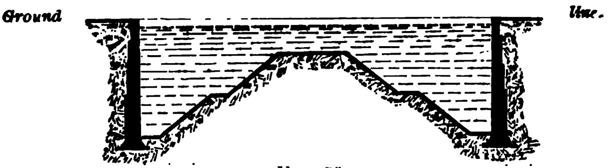


Fig. 56

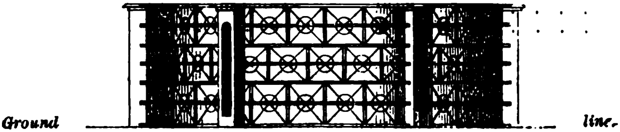


Fig. 57.

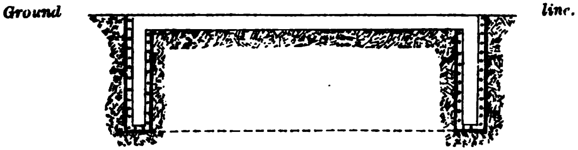


Fig. 58.

In excavated tanks, wherever the substratum is favourable, it is economical to leave a circular or conical mound in the centre. (Fig. 56.)

Tanks are occasionally formed by making a circular cutting in the ground, and erecting therein an iron annular channel to contain the water, the intervening central space being also covered with water, but only to a few inches depth. These are called "Annular Tanks." (Fig. 58.)

Excavation for Tank.

The width of the excavation for a tank depends on the nature of the substrata encountered, whether clay, shale, gravel, sand, &c., unless a complete system of shoring by means of timber all round is adopt

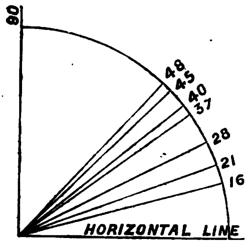


FIG. 59.

Natural Slope or Angle of Repose of Earths with Horizontal Line.

(Fig. 59.)

Sand, dry . .	average	37°	or	1·33	to	1
Sand, damp . .	„	21°	„	2·63	„	1
Shingle and gravel	„	40°	„	1·2	„	1
Clay, drained . .	„	45°	„	1·0	„	1
Clay, wet . . .	„	16°	„	3·3	„	1
Earth, compact .	„	48°	„	0·9	„	1
Peat or vegetable earth	„	28°	„	1·89	„	1

Weight of various Earths and Rocks.

	Per Cubic Yard.			Per Cubic Yard.	
Sand, dry . . .	about 2430	lbs.	Marl	„ 2900	„
Sand, damp . .	„ 3200	„	Shale.	„ 4370	„
Shingle and gravel	„ 2850	„	Chalk	„ 4000	„
Clay	„ 3240	„	Sandstone . . .	„ 4250	„
Mud	„ 2700	„	Slate	„ 4860	„

Materials of which Tanks are constructed.

Tanks are constructed of stone (either built or excavated from the solid rock), brick, concrete, cast or wrought-iron, or a combination of iron with the other materials.

The kind of material employed is regulated, as a rule, by the character of the district where the gasworks are situated, and the nature of the ground whereon the erection is to be. If the neighbourhood abounds in stone, the probability is that that will be the cheapest, and will consequently be adopted in the construction of the tank. But even in districts where stone is plentiful, if this is of a hard nature, the expense of dressing is such as to make the tank more costly than if built of bricks, though the latter may have to be brought from a distance. In places distant from a supply of building material, and to which the latter has to be brought by conveyance, brick will generally be chosen as the most suitable.

On the other hand, where the ground is of such a character as would entail an extraordinary outlay in securing a good foundation, or where it is unsafe for a brick or stone structure, or, again, where the sinking of a tank is almost impossible, owing to the presence of a large body of inflowing water through the strata, as by the sea-side, or contiguous to some rivers, the best class of tank to be adopted is one made of cast or wrought-iron plates bolted together, the joints being made water-tight with iron cement. It is only under such circumstances that iron tanks are adopted, as their cost is much greater than either brick or stone, and the erection of a tank above ground is disadvantageous in many respects.

It may happen that the ground is of such a nature as to render the construction even of an iron tank upon it unsafe; or there may be a slope or embankment in dangerous proximity. In such cases recourse may be had to piling to give it solidity and prevent movement.

Masonry tanks, being porous, are generally built with a backing of clay puddle behind the walls and in the bottom; but the puddle can be dispensed with by lining the tank with a coat of neat Portland cement about 1 inch in thickness. Mortar composed of cement and clean sharp sand in equal proportions by measure, makes a watertight lining, provided it is carefully polished to a smooth face with a steel trowel.

A lining of 4½ inch brickwork, with a space between the tank wall and the lining 1 inch wide, filled with neat cement, is also occasionally adopted.

The walls of a tank so treated being impervious to water, require to be made somewhat stronger, and the backing more carefully consolidated, than where puddle is employed, because there is no fluid pressure outside to equalize the fluid pressure within the tank.

When a brick or stone tank, built in blue lias lime mortar, is of large dimensions, the walls may be strengthened at intervals of 2 or 3 feet apart, by rings 2 or 3 feet in width, of the brick or stone laid in Portland cement mortar.

Hoop-iron, built at intervals into the masonry or concrete, is occasionally used for giving strength to the walls of a tank. When the diameter is great, and particularly in tanks where no puddle is employed, flat bar-iron hoops, braced or tightened by screws, are also sometimes placed round the outside.

The bricks used in building a tank should be thoroughly well wetted before being laid, to cause the mortar to adhere.

In time of severe frost all brick and stone work should cease.

To prevent injury in time of rain, and especially in winter when a sudden frost might supervene, the top of the new walling should be covered with weather boards.

Concrete.

Blue lias lime concrete (for foundations)—	By measure.
Gravel, shingle, broken stone, bricks, or old retorts, 1½ to 2 inches cube	6 parts.
Clean sharp sand	2 parts.
Blue lias or other hydraulic lime	1 part.

Portland cement concrete (for tank walls)—	
Gravel, shingle, broken stone, bricks, or old retorts, 1½ inches cube	7 parts.
Clean sharp sand	2 parts.
Portland cement	1 part.

Mr. J. Douglas gives the following useful instructions for mixing or preparing the concrete:—"A platform, about 20 feet square, of deals, should be laid on the ground to ensure the clean mixing of the materials. The measure for the material is simply a square box without top or bottom, and should contain, as a convenient quantity, about half a yard. It should be twice as many inches deep as the proportions of cement and ballast. For instance, if the cement is 1 in 8, it should be 16 inches deep. Inside, at 2 inches from the top, nail a lath all the way round; and after placing the measure at one end of the platform, fill the box with shingle or ballast to the level of the lath, and complete with cement, striking the cement level with a straight-edge. The box measure can then be lifted up and removed, when the cement will fall down over and among the aggregate, and the whole mass should [illegible] twice turned over *dry*. Water can then be added through a and the whole turned twice over again. As little water should be added as possible, but enough to thoroughly moisten the whole mass. The concrete is then fit for use. In dry weather it is necessary to keep the work damp, as, if there is not sufficient water to enable the cement to set—about 11½ per cent.—the concrete will be useless. It is also important to thoroughly wet the previous work on which the fresh concrete is to be laid."

Concrete is best placed in position from barrows wheeled close up; it should then be well and solidly rammed down. To tip it from a height (as was formerly the practice) is objectionable, as tending to disintegrate the ingredients of which it is composed.

Asphalte or tar concrete has never (so far as I am aware) been tried for a holder tank, but there is no reason why it should not answer admirably for that purpose. Its composition is as follows:—

	By measure.
Coal tar	6 parts.
Sifted lias lime	2 parts.
Gravel, shingle, broken stone, bricks, or old retorts, not more than 1½ inches cube	7 parts.
Clean sharp sand	2 parts.

The tar and lime to be first mixed together, and the other materials added. All to be thoroughly dry.

The kind of Mortar employed.

In the construction of brick or stone tanks, hydraulic mortar or cement mortar, either one or the other, or both, is invariably used. The following is their composition:—

Hydraulic Mortar.	By measure.
Best blue lias lime	1 part.
Clean sharp river sand	2 parts.

or,

Best blue lias lime	1 part.
Burnt clay	2½ parts.

or,

Best blue lias lime	1 part.
Puzzolana	1 part.
Clean sharp sand	6 parts.

Cement Mortar.

Cement, Portland	1 part.
Clean sharp sand	3 parts.

The lime should be fresh burnt, and not more than sufficient of the mortar for a day's work prepared at once. The cement mortar should only be made as it is being used.

The characteristics of good Portland cement are thus succinctly stated by Mr. Faija:—"In colour it should be of a dull bluish grey; and should have a clear, sharp, almost floury feel in the hand; it should weigh from 112 lbs. to 118 lbs. per striked bushel (87 to 92 lbs. per cubic foot), and when moulded into a briquette, or small testing-block, and soaked in water for seven days, should be capable of resisting a tensile strain of from 300 to 400 lbs. per square inch. The cement should, during the process of setting, show neither expansion nor contraction."

Asphalte or Tar Mortar.

	By measure.
Coal tar	2 parts.
Sifted lime	2 parts.

e tar and lime to be mixed together, and sand, in a thoroughly tate, to be afterwards added.

Puddle.

' puddle, clay mixed with one-third sand, silt, or soil free from able fibre, is preferable to pure clay, being firmer in texture, and iable to crack when dry. It should be prepared outside of the h, put in in thin layers as the wall of the tank is built, kept ened, trodden well in with the feet, and backed up with earth illy pounded. A cubic yard of puddle weighs about 2 tons.

Iron Tanks.

iron tanks the flanges of the bottom plates should always be ; whilst those for the sides should be *outside*, and the plates d break joint with each other throughout.

ı piers, or piers of brick, stone, or concrete, are erected at equal ıces apart round the outside of iron tanks, for the purpose of rting the gasholder columns. If the tank is of small dimensions, lumns may be bolted to strong brackets secured to the upper tier e plates.

Leakages from Iron Tanks.

kages of water from iron tanks may often be greatly reduced or ther stopped by emptying a bushel or two of horse-dung into the contiguous to the escape. A handful of fine iron filings sprinkled y over the dung will be found of advantage. By this simple expe- very heavy escapes have frequently been reduced to a mere drip n the space of a few minutes.

Dry Wells.

dry or stand-pipe well is not necessarily the invariable accom- ıent of a gasholder tank. Some engineers prefer to dispense with gether.

ny of the largest tanks are made without dry wells, the inlet and pipes being of such ample diameter as to admit of their exami- ı and repair, if need be, from the inside.

advantage supposed to be gained by providing a dry well is the y which it affords of access to the inlet and outlet pipes, both al and horizontal, in case of fracture, without disturbing the e or other backing of the tank wall.

small tanks it is not unusual to form a recess in the tank wall in ı the inlet and outlet pipes are placed, and are thus accessible the tank is emptied of water.

Thickness of Tank Walls.

walls of masonry tanks (brick, stone, and concrete) are never ed, unsupported, to resist the pressure of the water acting upon sides, but are invariably built under the surface level of the d within the space of an excavation made for that purpose, and a backing of earth carefully rammed all round them. This earth ng usually offers a resistance to the pressure of the water within the tank, greater than the combined weight of the wall, and the cohesive nature of its component ingredients; and consequently in designing a tank wall, this fact is allowed for, and a deduction made from the calculated unsupported thickness of the masonry.

In the well-known *Mémoire* by M. Arson, a translation of which, by Dr. Pole, is given in "King's Treatise" (Vol. II., p. 181 *et seq.*), the author investigates this subject with his usual ability. After some preliminary observations on the nature of the ground, and the choice and placing of material, he proceeds to a consideration of the forces and resistances in a gasholder tank of masonry, and deduces the following formulæ:—

As to the Pressure of the Water.

(1) $S\ D\ \frac{H^3}{6} =$ *the total force of the water.*

Then as to the threefold resistance to this force.

(1) $C\ D^1\ \frac{H^2}{2} =$ *the resistance of the earth backing.*

(2) $\frac{P\ E^2\ D^1\ H}{2} =$ *the resistance of the weight of the masonry.*

(3) $K\ H^2\ E =$ *the resistance due to cohesion.*

Adding the combined resistance from the three sources together, we have—

$$C\ D^1 \frac{H^2}{2} + \frac{P\ E^2\ D^1\ H}{2} + K\ H^2\ E.$$

And to produce stability of the tank these must be greater than the effect of the pressure of the water—

$$S\ D\ \frac{H^3}{6}$$

where D = Internal diameter of the tank in feet.
E = Thickness of the wall (average) in feet.
D^1 = External diameter of the tank in feet.
H = Height of wall in feet.
S = Weight of a cubic foot of water.
C = Resistance of the earth backing in lbs. per sq. foot.
P = Weight of a cubic foot of the masonry.
K = Cohesive force per sq. foot.

Applying these formulæ to one of the examples of tanks actually constructed, let us see how they work out. Take the tank described on pp. 135-6:—

D = Internal diameter of tank, 122 feet.
E = Average thickness of wall, 2½ feet.
D^1 = External diameter, 127 feet.
H = Height (or depth), 24 feet.
S = Weight of a cubic foot of water, 62·5 lbs.
C = Resistance of the earth backing, per sq. foot, clay and earth, say average 1200 lbs.
P = Weight of a cubic foot of the masonry, 112 lbs.
K = Cohesive force per sq. foot, bricks in 1 Portland cement to 3 sand, mortar, 31,680 lbs.

Then—

$$(1)\quad S\,D\,\frac{H^3}{6} = 62{\cdot}5 \times 122\,\frac{24^3}{6} = 17{,}568{,}000 = \text{total force of the water in lbs.}$$

$$(1)\quad C\,D^1\,\frac{H^2}{2} = 1200 \times 127\,\frac{24^2}{2} = 43{,}891{,}200 = \text{resistance of earth backing.}$$

$$(2)\quad \frac{P\,E^2 D^1 H}{2} = \frac{112 \times 2{\cdot}5^2 \times 127 \times 24}{2} = 1{,}066{,}800 = \text{resistance of weight of masonry.}$$

$$(3)\quad K\,H^2 E = 31680 \times 24^2 \times 2{\cdot}5 = 45{,}619{,}200 = \text{resistance due to cohesion.}$$

$$90{,}577{,}200 = \text{total resistance in lbs.}$$

or about five times the pressure of the water, which is an ample margin for safety.

It has already been pointed out that the walls of brick tanks, which are porous in some degree, having a backing of clay puddle behind and over the tank bottom, are placed in equilibrium by the water on both sides, and therefore do not require to be of as great a thickness as those with an internal lining of cement impermeable to water. In the latter case special care should be taken to see that the earth backing is thoroughly consolidated behind the wall, so that the pressure of the water against the tank may be transmitted thereto direct, without danger of rupture to the masonry.

When it is required to ascertain the thickness of any portion of a tank wall to resist the force of the water pressing against it, the formula as under is applicable:—

$$\frac{P\,D}{K - P} = \text{thickness in inches.}$$

Where P = the pressure of the water in lbs. per square inch.
D = the radius of the tank in inches.
K = the safe cohesive force in lbs. per square inch.

Example.—A brick and puddle tank set in Portland cement mortar is 122 feet in internal diameter and 24 feet deep to the surface of the rest stones. Required the thickness of the wall immediately above the footings.

The pressure of the water on each square inch will therefore be—

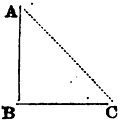
$$\frac{62{\cdot}5 \times 24}{144} = 10 \text{ lbs. pressure of water per square inch.}$$

The safe cohesive strength of the brickwork in Portland cement mortar (1 cement, 3 sand) may be taken at $\frac{220}{2} = 110$.

Then—

$$\frac{P\,D}{K - P} = \frac{10 \times 732}{110 - 10} = \frac{7320}{100} = 74 \text{ inches, nearly, or 6 ft. 2 in.}$$

the required thickness of the wall. It will be seen, however, that in this calculation no account has been taken either of the resistance offered by the weight of the masonry, or of the support given by the earth backing; so that the result obtained is the theoretical thickness of the wall to resist the pressure of the water without any backing. And as this latter may be taken as fully equal to the other, the thickness obtained by the calculation may be reduced by one-half—*i.e.*, to 3 ft. 1 in.—which will be the required thickness of the wall above the footings. The required thickness at any other depth may be found in like manner. The pressure of the water, which varies in proportion to the depth, may be represented by a right-angled triangle A B C, and, therefore, the thickness at the top would work out to nothing. It must not be overlooked, however, that the tank sides act as a retaining wall to the earth both during construction and at any time afterwards, when the water is withdrawn; and consequently its thickness should be graduated from the ascertained thickness at the base to about 2½ or 3 bricks width at the coping.



The thickness of 3½ feet at the base of the wall is too thin by more than one-half for an ordinary retaining wall of that height (24 feet), but it must be remembered that this apparent weakness is counterbalanced by the circular form of the structure, possessing as it does all the qualities of the arch, and being built up, both wall and backing, gradually throughout the complete circle from base to coping.

The conditions of cast and wrought-iron tanks are different. These being generally erected above ground, the resistance offered to the bursting force of the contained water is entirely due to the cohesive strength of the metal.

The same formula is applicable here, as will be seen from the next example of a cast-iron tank, where the safe cohesive strength of the iron is taken at 4000 lbs. per sectional square inch, its ultimate tenacity being 16,000.

EXAMPLE.—A cast-iron tank is 80 feet in internal diameter and 18 feet deep. Required the thickness of the lower ring of plates. These are generally 3 to 4 feet in depth, but the water pressure on the lowest foot may be taken.

Here $\frac{62{\cdot}5 \times 18}{144} = 7{\cdot}8$ lbs. pressure of water per square inch.

Then—

$$\frac{P\,D}{K - P} = \frac{7{\cdot}8 \times 480}{4000 - 7{\cdot}8} = \frac{3744}{3992{\cdot}2} = {\cdot}937,\text{ or say 1 inch,}$$

the required thickness; and so in like manner the required thickness of the several higher rings may be ascertained. This thickness may be slightly reduced by making allowance for the assistance given to the lower ring of plates by their attachment to the plates forming the bottom of the tank, and especially if iron hoops are employed round the outer circumference to give rigidity to the structure.

The safe cohesive strength of wrought-iron plates may be taken at 10,000 lbs. per sectional square inch.

Examples of Construction.

The following are examples of gasholder tanks constructed under moderately favourable circumstances. It will be found advisable in practice, in some instances, to increase the strength of the walls and footings, and even to put a bed of concrete below the latter where the underlying strata are of an unsatisfactory character.

BRICK TANKS.

Diameter, 21 ft. 6 in. Depth, 10 ft.

Footings, 3 single courses; width respectively, 3, 2½, and 2 bricks.
Wall, 1½ bricks thick for half the height, diminishing by an offset on the outside to 1 brick for the remainder.
Coping of wall, bricks set on edge, in cement.
Piers to support gasholder columns, 4 in number, brought up from foundation, and built in with the tank wall, each capped with a stone 2 ft. square, 8 in. thick, having 3 holes drilled in each for the holding-down bolts.
Rest stones, 8 in number, 15 in. square, 6 in. thick, laid on footings built at bottom of tank, bound in with the wall footings.
Puddled with clay, mixed with one-third fine sand, or soil free from vegetable fibre, 2 ft. thick at bottom; and at the sides, tapering from 2 ft. at the base to one foot at the top.
Bottom, flagged with 3 in. flags.
Bricks, best hard-burnt stocks.
Mortar, lias lime one-third, sharp river sand two-thirds.

Diameter, 33 ft. 6 in. Depth, 12 ft.

Footings, 2 double courses, width 3 and 2½ bricks.
Wall, 2 bricks thick for 8 ft. high, and 1½ bricks for the remaining 4 ft., set-off on outside.
Coping of wall, bricks on edge, laid in cement.
Piers, 4, bound in with wall, and brought up from foundation, each capped with a stone 2 ft. square, 9-in. thick, with 3 bolt-holes.
Stones at bottom of tank, for bottom curb of holder to rest on when down, 8; each 16 in. square, 6 in. thick, let into face of wall 2 in.; laid on footings.
Puddled with clay puddle, composed of two-thirds clay and one-third fine sand, trodden well together, 2 ft. thick at bottom and sides, tapering to 1 ft. 6 in. at top.
Bottom, flagged with yard flags, 3 in. thick.
Bricks, best hard-burnt stocks.
Mortar, composed of best lias lime, mixed with two-thirds sharp sand.

Diameter, 39 ft. Depth, 14 ft.

Footings, 2 double courses, 3½ bricks wide at base, diminishing by offsets to commencement of wall.
Wall, 2½ bricks at bottom to height of 6 ft.; next 4 ft., 2 bricks; remaning 3 ft. 6 in. to underneath coping, 1½ bricks thick.
Coping stones, 6 in. thick, laid in cement, and cramped together on the outside.
Piers, 5, brought up from foundation, each capped with a stone 2 ft. 6 in. square, 9 in. thick, with 4 bolt-holes.
Rest stones, 10, let 3 in. into face of wall, 18 in. square, 6 in. thick on footings.
Puddled with clay, mixed with one-third sand, 2 ft. thick at bottom and at the sides, tapering to 1 ft. 6 in. at top.
Bottom, brick paved.
Bricks, best hard-burnt stocks.
Mortar, lias lime, mixed with two-thirds sharp river sand.

Diameter, 51 ft. 6 in. Depth, 16 ft.

Footings, 2 double courses, 3½ and 3 bricks wide.
Wall, thickness at base to height of 7 ft., 2½ bricks; next 5 ft., 2 bricks; and remaining 4 ft., 1½ bricks.
Coping, bricks on edge, set in cement.
Piers, 5, carried up from foundation, each pier capped with a stone 3 ft. square, 9 in. thick, having 4 holes for holding-down bolts.
Rest stones, 10, 18 in. square, 6 in. thick, laid on footings, and let 3 in. into face of wall.
Puddled with clay, mixed with one-third sand, 2 ft. thick at bottom and sides, diminishing to 1 ft. 6 in. at top.
Bottom flagged with yard flags 3 in. thick, bedded on the puddle.
Bricks, best hard-burnt stocks.
Mortar, lias lime, mixed with two-thirds sharp river sand.

Diameter, 62 ft. Depth, 14 ft.

Footings, 4 courses; width respectively 4½, 4, 3½, and 3 bricks.
Wall, thickness at base to height of 5 ft., 2½ bricks; next 5 ft., 2 bricks; remaining 3 ft. to underneath coping, 1½ bricks.
Coping stones, 1 ft. thick, dressed to the proper radius, and laid in cement.
Piers, 6, brought up from foundation, bound in with tank wall, each capped with a stone 3 ft. square, 10 in. thick, with 4 bolt-holes.
Rest stones, 12, 18 in. square, 8 in. thick, laid on footings.
Mound left in bottom of tank, 8 ft. less in diameter than the latter, flagged round the base, other part pitched with random stones.
Puddled with clay two-thirds, intimately mixed with one-third sand; 2 ft. thick at bottom; the sides, 2 ft. at base to 1 ft. 6 in. at top.
Bricks, best hard-burnt stocks.
Mortar, lias lime, mixed with two-thirds sand.

Diameter, 83 ft. 6 in. Depth, 20 ft.

Footings, 4 courses; first course, double, 5 bricks in width; others single; 4½, 4, and 3½ bricks wide respectively.
Wall, from base to height of 7 ft., 3 bricks; next 7 ft., 2½ bricks; and remaining 6 ft., 2 bricks thick.
Coping, bricks set on edge, and laid in cement.
Piers, 9, brought up from foundation, each capped with a stone 4 ft. square, 10 in. thick, with 4 holes for holding-down bolts of columns.
Rest stones, 18, 24 in. square, 10 in. thick, laid on footings, and let 3 in. into sides of tank.
Puddled with clay, mixed with one-third sand, 2 ft. thick at bottom; the sides 2 ft. at base, tapering to 1 ft. 6 in. at top.
Centre pillar, to support crown of gasholder when down, built of brick, coated with cement.
Bottom, flagged with Yorkshire flags, 4 in. thick.
Bricks, best hard-burnt stocks.
Mortar, lias lime, mixed with two-thirds sharp river sand.

Diameter, 102 ft. Depth, 24 ft.

Footings, 6 bricks wide at base, diminishing by offsets to the bottom of wall.
Wall, thickness at base to 7 ft. in height, 4 bricks; next 7 ft., 3½ bricks; next 5 ft., 3 bricks; and remaining 4 ft., to coping, 2½ bricks thick.
Coping of stone, 1 ft. thick.
Piers, 12, carried up and built in with wall from foundation. Each capped with a stone 4 ft. square, 15 in. thick, with 4 bolt-holes.
Rest stones, 24, 2 ft. 6 in. square, 12 in. thick, let 4 in. into bottom of wall, and resting on footings.
Stones, 72 in number, 18 in. long, 12 in. by 12 in., built into tank wall, against which the channel guides are fastened.
Puddled with clay, mixed with one-third sand, 2 ft. thick at bottom; the sides, 2 ft. 6 in. at base, tapering to 1 ft. 6 in. at top.
Bottom, concreted over the puddle to the depth of 10 in.
Centre pillar, to support gasholder crown.
Bricks, best hard-burnt stocks.
Mortar, lias lime, mixed with two-thirds sharp river sand.

iameter, 102 ft. 6 in. Depth, 30 ft.

Footings, 1 double and 4 single courses, respectively 6, 5½, 5, 4½, and 4 bricks wide.
Wall, 3 bricks wide for 10 ft. high; next 10 ft., 2½ bricks; and remaining 9 ft. to coping, 2 bricks.
Coping of stone, 12 in. thick, not less than 4 ft. long each stone.
Strengthening rings, of brickwork, laid in cement, 5:

1st ring,	2 ft. 6 in.	from bottom,	7	bricks deep.
2nd do.	8 „ 6 „	do.	6	do.
3rd do.	14 „ 0 „	do.	6	do.
4th do.	19 „ 6 „	do.	5	do.
5th do.	24 „ 0 „	do.	4	do.

Piers, 12, brought up from foundation along with and bound into the wall, each capped with a stone 4 ft. 6 in. square, 15 in. thick, with 4 bolt-holes.
Rest stones, 24, 27 in. square, 12 in. thick, on footings, and let 4 in. into tank wall.
Puddled with clay, mixed with one-third sand, 2 ft. thick throughout.
Centre pillar, of brick, to support gasholder crown, cemented over.
Bottom concreted to the depth of 12 in. over the puddle.
Bricks, best hard-burnt stocks.
Mortar, lias lime, mixed with two-thirds sharp river sand.

iameter, 122 ft. Depth, 24 ft.

Concrete under footings of wall and rest stones, 12 in. thick and 10 ft. wide.
Footings, 8 bricks wide at base, diminishing by 8 offsets to the bottom of the wall.
Wall, thickness at base to 8 ft. 9 in. in height, 4 bricks; next 7 ft. 3½ bricks; next 4 ft. 6 in. 3 bricks; and remaining 3 ft. to coping, 2½ bricks thick. Batter of wall 1 in 100.

Coping of stone 9 in. thick, by 24 in. wide, and not less than 3 ft. 4 in. long.

Piers, 14, each 7 bricks square carried up and built in with wall from foundation and capped with a stone 5 ft. 4 in. square, 18 in. thick, and with 4 holding-down bolts to each.

Rest stones, 28, 3 ft. 6 in. by 2 ft. by 12 in. thick, let into wall 4½ in., and resting on footings.

Guide rail stones, 56 in number, built into tank wall, 28 of which are 2 ft. by 1 ft. 6 in. by 1 ft. 6 in., the remaining 28 being 2 ft. 6 in. by 1 ft. 6 in. by 1 ft.

Brick ring or apron extending 6 ft. from inside of tank wall at the bottom to form a floor, 3 courses of bricks thick laid flat.

Centre pillar of brickwork, 4 ft. diameter.

Mortar, Portland cement, 1 part; sand, 3 parts.

Bricks, picked common.

Puddle behind wall of tank, 24 in. thick at bottom, tapering to 18 in. at top. On cone in tank bottom 18 in. thick.

Concrete over surface of puddled cone in bottom, 6 in. thick.

Diameter, 145 ft. Depth, 55 ft.

Top of tank, 4 ft. above ground level.

Footings, 4 double courses, respectively 5 ft., 4 ft. 8 in., 4 ft. 4½ in., and 4 ft. wide.

Wall, to height of 10 ft. above footings, 3 ft. 7 in., or 4½ bricks thick; next 10 ft., 4 bricks; next 10 ft., 3½ bricks; next 15 ft., 3 bricks; next 5 ft., 2½ bricks; remaining 4 ft., exclusive of coping, 2 bricks thick.

Strengthening rings, or courses, 6 courses in every 5 ft. of height; also the 3 finishing courses, and the corresponding courses in piers, set in cement. The brickwork at no part carried higher than 5 courses of bricks, until the circle up to that level is completed, puddled, and backed up.

Coping of stone, 12 in. thick, bedded in cement.

Piers, 16, 4 ft. 3 in. wide, each capped with a stone 5 ft. square, 18 in. thick, for supporting columns; 4 holes in each for holding-down bolts; the said holding-down bolts, with cast-iron plate, built into each pier, 10 ft. below level of coping.

Rest stones, 32, let 4½ in. into face of wall, and resting on piers of brickwork forming part of the general footings.

Blocks of stone, 18 in. by 12 in. by 12 in., inserted in wall opposite each pier, for securing guides.

Cone in centre of tank, 6 ft. less in diameter at the base than the interior of tank; lower part, to height of 20 ft., paved with 4 courses of brickwork; upper part, of clay only.

Puddle, not less than 18 in. in thickness, and kept constantly well moistened; the earth being firmly pounded in behind.

Bricks, best hard burnt stocks.

Mortar, composed of 1 part fresh burnt lias lime, to 3 parts of clean, sharp river sand; not more than sufficient for one day's work made at one time.

Cement, fresh burnt, with equal proportions of sand, mixed as it is being used.

Dry, or stand pipe well, 15 ft. diameter, 63 ft. deep, paved with *3 courses of brick*work on edge, set in cement.

Diameter, 154 ft. Depth, 40 ft. 6 in.

Foundation of concrete 12 in. thick, 13 ft. wide under piers, and 11 ft. wide under walling.

Wall, starts from concrete foundation without footings, 5 bricks thick for a height of 16 ft. 10 in.; next 4½ bricks for 6 ft. 5 in. deep; next 4 bricks for 6 ft. 5 in.; next 3½ bricks for 6 ft. 5 in., and 3 bricks the remaining height.

Coping of stone, 12 in. by 2 ft. 3 in., in lengths not less than 4 ft. 6 in.

Piers, 16 in number, 6 ft. square from bottom to top, capped with hard Yorkshire stones, 6 ft. square and 2 feet thick, with 4 bolt-holes in each.

Rest stones, 32, 4 ft. 10 in. by 2 ft. by 1 ft., built 4½ in. in tank wall.

Guide rail stones, 144 in number, 112 of which are 2 ft. by 1 ft. 9 in. by 1 ft., and the remaining 32 being 2 ft. by 1 ft. 9 in. by 1 ft. 6 in.

Puddled with clay 24 in. thick over surface of mound in bottom, and behind tank wall.

Brick apron, 2 ft. thick and 6 ft. wide, round bottom of tank wall inside, upon which the rest stones are set.

Centre pillar of brick, 6 ft. square at bottom and 6 ft. 3 in. square at top, capped by a stone 12 in. thick.

Mortar, Portland cement, 1 part; sand, 3 parts.

Bond, English; alternate courses of headers and stretchers throughout.

Dry well, 10 ft. in diameter, 48 ft. 6 in. deep.

Diameter, 182 ft. Depth, 40 ft.

Footings, 3 ft. deep below tank bottom, in 3 equal set-offs, placed on elm sleepers, 9 in. by 4 in.

Wall, thickness at base to 15 ft. in height 4½ bricks; next 15 ft. 4 bricks; next 5 ft., 3 bricks, and remaining 4 ft., 2½ bricks thick.

Coping, Bramley fall stone, 12 in. thick and 24 in. wide.

Piers, 28, 6 ft. thick from inside tank to outside pier, and 8 ft. 9 in. wide side to side, capped with granite blocks, 5 ft. 3 in. square and 2 feet thick, with 4 bolt holes in each.

Rest stones, 28, built in wall 12 in., are each 4 ft. by 2 ft. 6 in. by 12 in. thick.

Guide rail stones, 112 in number, 18 in. by 12 in. by 12 in.

Puddled with clay on cone in bottom of tank, under footings, and behind tank wall a uniform thickness of 24 in.

Cone at bottom covered over the clay with 9 in. of concrete, and paved with a layer of bricks on edge, set in cement.

Centre pillar of brickwork, 7 ft. 6 in. square, capped with granite block, 2 ft. thick, the whole on a foundation of concrete.

Bricks, best hard-burnt stock bricks.

Mortar, blue lias lime mortar.

Brick ring or apron, 3 ft. thick, extending 6 ft. 6 in. from inside of tank wall at the bottom, to form a floor.

Diameter, 200 ft. Depth, 36 ft.

Footings, laid on elm boards 1½ in. thick, placed on the puddle, are 9 bricks wide at base, diminishing by 2¼ in. offsets to bottom of wall.

Wall, thickness at base to 12 ft. in height, 5 bricks; next 6 ft., 4½ bricks; next 5 ft., 4 bricks; next 5 ft., 3½ bricks; next 5 ft., 3 bricks, and the remaining portion, 2½ bricks; being finished at top, to form a coping, with Staffordshire blue bricks set on edge in cement.
Piers, 22 in number, 5 ft. 6 in. from inside tank to outside the pier, and 7 ft. wide from side to side, surmounted by Bramley Fall column stones, 6 ft. by 5 ft. 6 in., by 1 ft. 4 in. thick, with 4 holes in each.
Piers, intermediate, 22 in number, 5 brick lengths square, brought up from bottom, and capped with stones, 2 ft. square, and 1 ft. 6 in. thick.
Rest stones, 44, 4 ft. 6 in. by 3 ft. by 1 ft. 3 in. thick, set into wall 4½ in. and bedded on concrete.
Guide rail stones, 44, 2 ft. square by 1 ft. 6 in.
Puddled with clay, over cone in centre, and under footings 2 ft. 6 in. thick, behind tank wall 2 ft. thick at bottom, tapering to 1 ft. 6 in. at top.
Concrete apron, 2 ft. thick, extending 9 ft. from tank wall all round.
Cone, covered with 6 in. of concrete over the clay puddle.
Bricks, well burnt Oldbury brown bricks.
Mortar, blue lias lime, 1 part; sand, 2½ parts.
Bond, English, alternate courses of headers and stretchers throughout.
Hoop-iron bond, every sixth course in height, 1¼ in. by 1-16th in. is inserted as follows:—In the 5 bricks thick part, 5 rows are laid in the thickness of the wall at equal distances apart; in the 4½ and 4 bricks thick part, 4 rows; 3½ and 3 bricks part, 3 rows; and 2 rows for the remaining height.
Shallow dry well, 12 ft. diameter, 20 ft. deep.

Diameter, 203 ft. 6 in. Depth, 38 ft.

Footings, bottom course, 7 bricks wide 4 bricks deep, and 4 single courses, respectively 6, 5½, 5, and 4½ bricks wide.
Wall, thickness for a height of 20 ft., 4 bricks; next 9 ft., 3½ bricks; next 8 ft., 3 bricks.
Coping stone, 24 in. wide, 12 in. thick.
Strengthening rings of brickwork laid in cement, 5, divided equally throughout the depth of tank wall, 10 bricks each in depth.
Piers, 18, on foundations brought up from bottom of tank footings, and bound in with wall, each capped with a stone 6 ft. square, 18 in. thick, 4 holes for bolts, the latter with plate built into pier 10 ft. below top of coping.
Rest stones, 36, 4 ft. square, 12 in. thick on footings brought up from bottom of wall footings.
Puddled with clay mixed with one-third sharp sand, and not less than 2 ft. thick in any part.
Bottom concreted over the puddle to the depth of 12 in.
Bricks, best hard-burnt stocks.
Mortar, 1 part lias lime to 2 parts sharp river sand.

Diameter, 218 ft. Depth, 44 ft. 6 in.

Foundation of concrete 2 ft. thick, 9 ft. 5 in. wide, including apron.
Wall, thickness at base to 20 ft. in height, 5 bricks; next 5 ft.

4½ bricks; next 5 ft., 4 bricks; next 5 ft., 3½ bricks; next 5 ft. 3 bricks, and the remaining portion 2½ bricks; 7 circular bands of brickwork, 6 courses deep each, and extending through the full thickness of the wall are built in equidistantly in the height of the wall set in Portland cement mortar, the intervening portions of the wall being set in hydraulic lime mortar, all in English bond.

Coping of Yorkshire stone, 2 ft. 5 in. by 6 in., in 5 feet lengths, projecting 1 inch over wall.

Piers, 24, each 7 ft. from inside tank wall to outside of pier, and 5 ft. 6 in. wide, side to side, capped with Bramley Fall stones, 7 ft. by 5 ft. 6 in. by 2 ft., having 7 bolt-holes in each.

Piers, intermediate, 24, each 3 ft. 10 in. square, capped with stones 4 ft. by 4 ft. by 6 in.

Rest blocks of concrete, 48, each 4 ft. 6 in. long by 2 ft. wide, and standing 6 in. above the concrete apron.

Guide rail stones, 288, each 18 in. by 12 in. by 12 in., projecting 1 inch from face of tank wall.

Puddled with clay, not less than 18 in. at any part.

Truncated surface of cone paved with stones.

Mortar, blue lias hydraulic lime, 1 part; sand, 3 parts.

Cement mortar, Portland cement, 1 part; sand, 3 parts.

Concrete, Portland cement, 1 part; river ballast, 7 parts.

Shallow dry well, 12 ft. diameter, 26 feet deep.

COMPOSITE TANK.

Diameter, 152 ft. Depth, 31 ft.

Footings, 8 ft. 6½ in. wide at bottom, including apron, 2 ft. 6 in. thick.

Wall, brick faced, 9 in. thick, in English bond; backing of concrete; thickness at base, including the backing, to 13 ft. 9 in. high, 3 ft. 4½ in.; next, 8 ft. 6 in., 3 feet thick; and the next 8 ft. 6 in., 2 ft. 8 in., to the underside of coping.

Coping of stone, 1 ft. 10 in. by 12 in., in 3 ft. lengths.

Piers, 16, are 8 ft. from inside tank wall to outside pier and 4 ft. 6 in. wide from side to side, formed of 9-in. brickwork on 3 sides and filled in with concrete, the whole being capped with a stone 8 ft. by 4 ft. by 1 ft.

Rest stones, 2 to each pier, or a total of 32, each 4 ft. by 1 ft. 6 in. by 9 in.

Guide rail stones, 48, each 2 ft. by 1 ft. by 9 in.

Puddled with clay, 2 ft. thick throughout.

Cone, concreted over the clay puddle to a depth of 12 in. and rendered.

Centre pillar, solid brickwork, 6 ft. 6 in. diameter at top, the sides having a batter of 1 in 40; built on a foundation of concrete 10 ft. square and 8 ft. deep. Stone cap, 6 ft. diameter by 1 ft. thick, on which is placed a double layer of 4-in. oak planking.

Hoop-iron bond, tarred and sanded, 1½ in. wide, 1-12th in. thick, is

placed every 4½ ft. in height, in the proportion of 1 strip to every 4½ in. in thickness of the wall.
Mortar, Portland cement, 1 part; sand, 3 parts.
Concrete, Portland cement, 1 part; sand, 3 parts; coarse screened stones, 1½ in. diameter, 4 parts.
Dry well, 11 ft. diameter, 40 ft. deep to floor.

CONCRETE TANK.

Diameter, 184 ft. Depth, 47 ft.

Wall, 5 ft. thick at bottom, tapering on the outside to 2 ft. 3 in. at the top, built entirely of concrete, and rendered on inside with neat Portland cement, ¾ in. thick.
Piers, 20, each 8 ft. thick, of concrete entirely.
Rest blocks of concrete, 6 ft. long.
Puddle, none.
Cone, concreted over surface, 12 in. thick, and rendered with neat cement, ¾ in. thick.
Centre pillar, hollow, external diameter 14 ft., internal ditto 10 ft.
Concrete, Portland cement, 1 part; gravel, sand, ballast, burnt clay, old retorts, and clinkers, 7 parts.
Dry well, 10 ft. diameter, 53 ft. deep, built of concrete 2 ft. thick, and rendered outside with neat cement.

STONE TANK.

Diameter, 89 ft. Depth, 20 ft.

Footings, 2 courses. First course composed of stones at least 3 ft. 6 in. square, and 9 in. thick; second course, 3 ft. square, 9 in. thick, breaking joint at least 1 ft. on the vertical joint.
Wall, to underneath coping, built of stones not less than 16 in. on the inner face, dressed to the proper radius. No stone having less than 10 in. of a square joint, nor less than 18 in. on the bed, and 5 in. thick. Walling carried out in horizontal courses throughout the circumference of the tank, and backed up with good strong random. Two throughs to every superficial yard. Thickness of wall at base, random included, 2 ft. 8 in., gradually diminishing to 1 ft. 8 in. at top.
Coping of stones, 1 ft. 11 in. broad, 8 in. thick, and not less than 3 ft. 6 in. long, dressed to the proper radius, and laid in cement.
Piers, 9, bound in and built up along with the tank wall; a through of entire size every vertical yard, and capped with a solid cover 3 ft. 6 in. square, 15 in. thick, having 4 holes for foundation bolts of columns.
Rest or bearing stones, 18, throughs 2 ft. wide and 1 ft. thick built *in along with* wall footings, and projecting 1 ft. 9 in. into the *tank.*

Mound or cone in bottom of tank, covered with puddle to the depth of 24 inches, its base flagged with a course of yard flags 4 in. thick, the remainder pitched with dry rubble.

Pillar in centre of tank, capped with a solid stone 4 ft. square 15 in. thick, for supporting crown of gasholder when down.

Mortar, lias lime, one-third; sharp clean sand, two-thirds.

CAST-IRON TANKS.

Diameter, 33 ft. Depth, 15 ft.

Plates, not more than 4 ft. in length or width. All, except top course or tier, strengthened with diagonal ribs. Lowest tier ¾ in. thick; top tier ½ in. thick; intermediate and bottom plates ⅝ in. thick. Small brackets or snugs, projecting 4 in., cast 1½ in. below centre of side plates, to support the strengthening hoops.

Flanges, 3 in. wide, with brackets between the bolt-holes.

Bolt-holes, square, ⅝ in. and ½ in., and 6 in. apart, centres.

Bolts of bottom plates and two lower tiers of sides, ⅝ in.; all the others ½ in., square under head.

Hoops of flat wrought-iron, 3 in. by ⅝ in., bound round each tier of side plates with jaws and screws.

Joints, ½ in. thick, caulked with iron cement.

Diameter, 61 ft. Depth, 17 ft.

Plates, bottom, 1 in. thick, except outside row, 1⅛ in. thick. Sides first tier, 1⅛ in.; second, 1 in.; third, ⅞ in.; and 4th, ¾ in. thick. Depth, 4 ft. 3 in.; width, 4 ft. 9 in. Say, 40 plates in each tier. Snugs, projecting 4 in., cast on each plate, 2 in. below centre, to support the binding hoops.

Flanges, 3 in. wide, not less than ¾ in. thick; brackets ½ in. thick between the bolt-holes.

Bolt-holes, square, ¾ in.; 7 in. apart, centre to centre.

Bolts, ¾ in., square under head.

Hoops of flat-iron, 3½ in. by ¾ in., with suitable jaws and tightening screws bound round each tier of side plates.

Joints, ½ in. thick, caulked with iron cement.

Diameter, 101 ft. Depth, 22 ft. 8 in.

Plates, bottom, outside row 1¼ in., and remainder 1 in., except centre plate, 1⅛ in. Sides, first and second tiers, 1¼ in.; third tier, 1⅛ in.; fourth and fifth tiers, 1 in. thick. Width, 4 ft. 2¾ in. (say 75 plates in each tier); depth, 4 ft. 6½ in. Bearing bracket, projecting 5 in., cast on each plate, 2½ in. below centre, to support the strengthening hoops.

Flanges, 3¼ in. wide, equal to plates in strength; brackets ¾ in. between the bolt-holes.

Bolt-holes, square, 1 in.; 7 in. centre to centre.
Bolts, 1 in., square under head.
Hoops, flat-iron, 5 in. by 1¼ in., with jaws and screws, bound round each tier of side plates.
Joints, ½ in. thick, caulked with iron cement.

WROUGHT-IRON TANK.

Diameter, 51 ft. 4 in. Depth. 14 ft.

Plates ⅜ in. thick, both sides and bottom, with the exception of the outer row in the latter, and those to which the guide rails are fixed up the sides, which are ½ in. thick.
Curbs, of angle-iron, extending round the entire circumference of the tank outside; top curb 4 in. by 4 in. by ½ in.; two intermediate curbs or rings the same size, and bottom curb 4½ in. by 4½ in. by ½ in., all butt jointed, and with lapping pieces not less than 18 in. long, riveted to the side plates of the tank with ⅝ in. rivets 6 in. apart.
Vertical stays, 12 in number, serving as guides for the holder, 14 ft. long, formed of two 3 in. by 2½ in. by ⅜ in. angle-irons placed thus:—JL and riveted to the ½ inch plates up the sides before mentioned with rivets 6 in. apart.
Lap of plates, not less than 1½ in., riveted hot with ⅝ in. rivets 1½ in. centres.
Masonry standards to support columns.

ANNULAR OR RING TANKS.

Cast-Iron.

Diameter, 75 ft. Depth, 19 ft.

Plates, bottom or ring plates, 3 ft. 6 in. wide, 1 in. thick. Inner circles, 1 tier of plates only, 4 ft. deep, 1 in. thick; strengthened with 2 horizontal ribs, 2 in. deep by ¾ in. thick on side next centre of tank, and on other side with 2 vertical brackets, 9 in. at bottom diminishing to nothing at top, ¾ in. thick, with foot, 9 in. by 6 in. by ¾ in., on bottom of each bracket. Outer circle, 4 tiers, 4 ft. 9 in. deep, and 1 in., ⅞ in., ¾ in., and ⅝ in. thick respectively. 55 plates in the circumference. Snug, projecting 4¾ in. 2 in. below centre, to support binding hoops.
Flanges, 3¾ in. wide, equal to plates in strength, with brackets between the bolt-holes.
Bolt-holes square, ⅞ in.; 6 in. centre to centre.
Bolts, ⅞ in., square under head.

Hoops, flat-iron, 4 in. by 1 in., with suitable jaws and screws, bound round each tier of outside plates.
Joints, ½ in. thick, caulked with iron cement.

Diameter, 103 ft. Depth, 22 ft.

Plates, bottom or ring, 5 ft. wide, 1 in. thick. Inner circle, 1 tier of plates only, 4 ft. deep, 1 in. thick; strengthened with 2 horizontal ribs, 2 in. deep by ¾ in. thick on side next centre of tank, and on other side with 2 vertical brackets, 9 in. at bottom, diminishing to nothing at top, ¾ in. thick, with foot on bottom of each, 9 in. by 6 in. by ¾ in. Outer circle, 5 tiers, 4 ft. 5 in. deep, and 1¼ in., 1 in., ⅞ in., ¾ in., and ¾ in. thick respectively. 66 plates in the circumference. A snug or bearing bracket cast on each of the outside plates, 2½ in. below centre, and projecting 4 in. for supporting the binding hoops.
Flanges, 3 in. wide, 1 in. thick, with brackets between the bolt-holes.
Bolt-holes, ¾ inch square, 6 in. apart, centre to centre.
Bolts, ¾ in., square under head.
Hoops, flat-iron, 4½ in. by ¾ in. for bottom tier, 4½ in. by ⅝ in. for the others, with jaws and tightening screws.
Joints, ½ in. thick, caulked with iron cement.

Diameter, 110 ft. Depth, 24 ft. 2 in.

Plates, bottom or ring, 3 ft. 10 in. wide, ¾ in. thick. Inner circle 1 tier of plates only, 4 ft. deep, ¾ in. thick; strengthened with 2 horizontal ribs, 2½ in. broad by ¾ in. thick on side next centre of tank, and on the other side with 2 vertical brackets, 9 in. at bottom, diminishing to nothing at top, ¾ in. thick, with foot on bottom of each, 9 in. by 6 in. by ¾ in. Outer circle, 5 tiers, 4 ft. 10 in. deep, and 1¼ in., 1 in., ⅞ in., ¾ in., and ¾ in. thick respectively. 66 plates in the circumference. A bearing bracket cast on each of the outside plates, 2½ in. below centre, and projecting 4 in., for supporting the binding hoops.
Flanges, 3 in. wide, and same strength as the respective plates; brackets between the bolt-holes.
Bolt-holes, ⅞ in. square, 6 in. apart, centres.
Bolts, ⅞ in., square under head.
Hoops, flat-iron, 5 in. by ¾ in. for the bottom tier, and 4½ in. by ⅝ in. for the others, with suitable jaws and tightening screws.
Joints, ½ in. thick, caulked with iron cement.

Wrought-Iron.

Diameter, 127 ft. Depth, 20 ft. 8 in.

Annular space, 3 ft. 9 in. wide.
Plates, bottom or ring plates ½ inch thick; sides five rows deep; first and second row of plates from bottom ½ in. thick; third

and fourth rows 7-16ths in. thick, and the fifth or top row ⅜ in. thick; lap of plates, 3 in.; the top of the inner row of plates being 8 in. lower than the outer row; angle-iron curbs in bottom, 4 in. by 4 in., by ⅜ in. thick; the ½ in. and 7-16ths in. plates riveted with ⅞ in. rivets, 2½ in. apart, and the ⅜ plates by ¾ in. rivets, 2 in. apart.

Curbs, top outer curb of angle-iron 5 in. by 5 in. by ½ in.; top inner curb of angle-iron 3 in. by 3 in. by ½ in.; both riveted with ¾ in. rivets, 6 in. apart.

Standards, 18, box form, 15 in. by 9 in., of ⅜ in. plates on three sides, 3 in. by 3 in. by ½ in. angle-iron to secure same to side sheets and extending round the bottom of the standard at its lower end, and 5 in. by 5 in. by ⅜ in. angle-iron round the top to form a base for the columns, all riveted at 6 in. apart with ¾ in. rivets; two of these standards form the inlet and outlet pipes, for which purpose they are continued under the annular space and up the inside of the inner ring of side sheets, and riveted with ¾ in. rivets as before, but only 2 in. apart.

GASHOLDERS.

The holder or floating vessel (Fig. 58) is the storage reservoir for the gas, and it serves the all-important purpose of equalizing the distribution of the gas under pressure, and ensures an unbroken continuity of supply. In form it is invariably cylindrical, like an inverted cup, and works freely up and down in the tank.

The holder may be either single (Fig. 60), or telescopic (Fig. 61), and the latter may be in either two or more lifts. Two lifts are generally adopted, but some of the largest holders recently constructed are in three lifts.

When the holder is made in the telescopic form, its capacity is nearly double or treble (as the case may be) the capacity of the single lift holder for equal dimensions of tank. Ground space and capital are thus economized by its adoption.

Telescopic holders require great care in construction and working—*first*, to ensure accuracy in the "cupping" of the water-lute or seal, and, *second*, to prevent the water in the lute from freezing, which endangers the action of the vessel, or causes distortion, and imperils the lighting of the district.

Holders, whether single or telescopic, are counterbalanced or not, as is found desirable or necessary. When the diameter of the holder is more than twice the depth, counterbalance weights are not required, especially where an exhauster on the one hand, and a governor on the other, are employed, as is the case in all but the smallest gas-works. When the diameter and depth more nearly approximate, it will generally be found of advantage to reduce the pressure by counterbalancing. The large three-lift telescopic holder, 214 ft. in diameter, *and 159 ft. 9 in.* total depth, at the South Metropolitan Gas-Works, *is not counterbalanced.*

e crown or roof of a holder may be either trussed (Fig. 60), or ussed (Fig. 61). In the latter case the top curb requires to be made

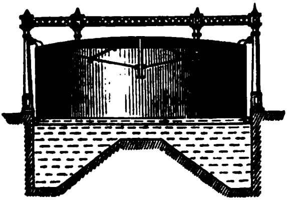


Fig. 60.

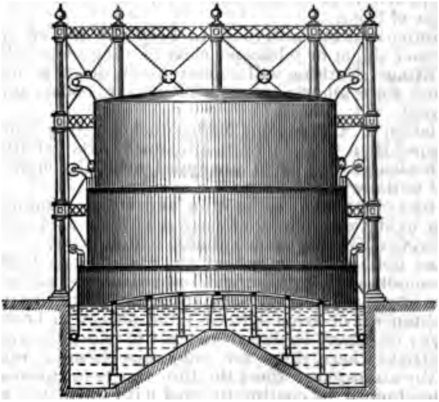


Fig. 61.

iently strong to resist the pressure of the gas exerted on the rside of the roof, which tends to distort the curb. A framework od or iron is required to be erected within the tank to support ntrussed roof when the holder is empty of gas, and resting on the ng stones.

e usual rise given to the roof or crown of a holder is 5 per cent., e-twentieth of the diameter.

Gasholder Capacity.

e holder or holders should be of capacity sufficient to contain at the 24 hours' maximum production of gas. An excess in capa- though not absolutely necessary, is found advantageous in point nvenience and economy, where the rate of consumption is liable ctuations by the non-lighting of the public lamps during the hours of moonlight; and where, as in manufacturing towns and districts, the large manufactories, generally the heaviest gas consumers, being closed on Saturday nights and Sundays, the production for these two days (unless Sunday labour is partially avoided) is greatly in excess of the consumption.

Precautions to be observed in the working of Gasholders.

Telescopic holders in winter are liable to be thrown out of order by the freezing of the water in the cup between the lifts. When the lower lift is down, the upper lift in its progress downwards rolls the ice and snow in the lute into hard lumps, often, if not removed, throwing the vessel out of plumb, and even fracturing the columns. Great care should therefore be taken to keep the water-lute clear; and where steam can be readily applied, it is of the utmost service in accomplishing this object in time of frost.

Another important precaution is to keep the top or crown of the holder, whether single or telescope, clear of snow, especially when the latter is drifting. Nothing will sooner break down a holder and its guide framing than allowing a mass of snow to collect and lie on one side of the roof.

The oscillation of a telescopic holder during strong winds is greater when uncupped than when the lifts are joined. Its liability to damage from wind is also greater when uncupped, even although less surface is presented to the wind's action.

The sheeting of a holder, being thin and the portion most liable to wear out by oxidation, should be coated outside at least once a year with good oxide of iron or other suitable paint, or tar.

It happens not unfrequently that the roof of a gasholder becomes pitted with small pin-holes from which there is a considerable and constant escape of gas. This may arise from the inferiority of the iron in the first instance; or from allowing the sheets to become oxidized before fixing; or it may be due to neglect to paint the vessel when in use. In districts where there are numerous chemical works, the impurities in the atmosphere affect the thin sheets in this manner. The leaks may be stopped by coating the roof with warm tar, and riddling dry sand or cement over it through a sieve, at the same time rubbing the mixture well in with a stiff brush.

Recipe for coating a gasholder:—

1 gallon of tar.
½ lb. of slaked lime.
½ lb. of pitch.
½ lb. of tallow.
½ pint of coal naphtha.

Dissolve the pitch and mix the lime in the tar by heating them in a boiler, being careful not to boil them; ladle out the hot liquid into a bucket, and then add the tallow and the naphtha. Stir the mixture occasionally, and with a brush paint it on the holder before it grows cold.

TABLE

Giving the CAPACITY OF GASHOLDERS *in Cubic Feet for every Foot in Depth, and from* 20 *to* 150 *Feet in Diameter, advancing Half a Foot at a Time.*

Diameter of Holder in Ft.	Capacity in Cub. Ft. for every Foot in Depth of Holder.	Diameter of Holder in Ft.	Capacity in Cub. Ft. for every Foot in Depth of Holder.	Diameter of Holder in Ft.	Capacity in Cub. Ft. for every Foot in Depth of Holder.	Diameter of Holder in Ft.	Capacity in Cub. Ft. for every Foot in Depth of Holder.	Diameter of Holder in Ft.	Capacity in Cub. Ft. for every Foot in Depth of Holder.
20	314·16	46½	1698·23	72½	4128·25	98½	7620·14	124½	12173·89
20½	330·06	47	1734·94	73	4185·39	99	7697·70	125	12271·87
21	346·36	47½	1772·05	73½	4242·92	99½	7775·65	125½	12370·24
21½	363·05	48	1809·56	74	4300·85	100	7854·00	126	12469·01
22	380·13	48½	1847·45	74½	4359·16	100½	7932·73	126½	12568·16
22½	397·60	49	1885·74	75	4417·87	101	8011·86	127	12667·71
23	415·47	49½	1924·42	75½	4476·97	101½	8091·38	127½	12767·65
23½	433·73	50	1963·50	76	4536·47	102	8171·30	128	12867·99
24	452·39	50½	2002·96	76½	4596·35	102½	8251·60	128½	12968·72
24½	471·43	51	2042·82	77	4656·63	103	8332·30	129	13069·84
25	490·87	51½	2083·07	77½	4717·30	103½	8413·40	129½	13171·35
25½	510·70	52	2123·72	78	4778·37	104	8494·88	130	13273·26
26	530·93	52½	2164·75	78½	4839·83	104½	8576·76	130½	13375·55
26½	551·54	53	2206·18	79	4901·68	105	8659·03	131	13478·24
27	572·55	53½	2248·01	79½	4963·92	105½	8741·69	131½	13581·33
27½	593·95	54	2290·22	80	5026·56	106	8824·75	132	13684·80
28	615·75	54½	2332·83	80½	5089·58	106½	8908·20	132½	13788·67
28½	637·94	55	2375·83	81	5153·00	107	8992·04	133	13892·94
29	660·52	55½	2419·22	81½	5216·82	107½	9076·27	133½	13997·59
29½	683·49	56	2463·01	82	5281·02	108	9160·90	134	14102·64
30	706·86	56½	2507·19	82½	5345·62	108½	9245·92	134½	14208·08
30½	730·61	57	2551·76	83	5410·62	109	9331·33	135	14313·91
31	754·76	57½	2596·72	83½	5476·00	109½	9417·14	135½	14420·14
31½	779·31	58	2642·08	84	5541·78	110	9503·34	136	14526·75
32	804·24	58½	2687·83	84½	5607·95	110½	9589·93	136½	14638·76
32½	829·57	59	2733·97	85	5674·51	111	9676·91	137	14741·17
33	855·30	59½	2780·51	85½	5741·47	111½	9764·28	137½	14848·96
33½	881·41	60	2827·44	86	5808·81	112	9852·05	138	14957·15
34	907·92	60½	2874·76	86½	5876·55	112½	9940·21	138½	15065·73
34½	934·82	61	2922·47	87	5944·69	113	10028·77	139	15174·71
35	962·11	61½	2970·57	87½	6013·21	113½	10117·71	139½	15284·08
35½	989·80	62	3019·07	88	6082·13	114	10207·05	140	15398·84
36	1017·87	62½	3067·96	88½	6151·44	114½	10296·79	140½	15503·99
36½	1046·35	63	3117·25	89	6221·15	115	10386·91	141	15614·53
37	1075·21	63½	3166·92	89½	6291·25	115½	10477·43	141½	15725·47
37½	1104·46	64	3216·99	90	6361·74	116	10568·34	142	15836·80
38	1134·11	64½	3267·46	90½	6432·62	116½	10659·64	142½	15948·52
38½	1164·15	65	3318·31	91	6503·89	117	10751·34	143	16060·64
39	1194·59	65½	3369·56	91½	6575·56	117½	10843·42	143½	16173·15
39½	1225·42	66	3421·20	92	6647·62	118	10935·90	144	16286·05
40	1256·64	66½	3473·23	92½	6720·07	118½	11028·78	144½	16399·34
40½	1288·25	67	3525·66	93	6792·92	119	11122·04	145	16513·03
41	1320·25	67½	3578·47	93½	6866·16	119½	11215·70	145½	16627·11
41½	1352·65	68	3631·68	94	6939·79	120	11309·76	146	16741·58
42	1385·44	68½	3685·29	94½	7013·81	120½	11404·20	146½	16856·45
42½	1418·62	69	3739·28	95	7088·23	121	11499·04	147	16971·70
43	1452·20	69½	3793·67	95½	7163·04	121½	11594·28	147½	17087·35
43½	1486·17	70	3848·46	96	7238·24	122	11689·89	148	17203·40
44	1520·53	70½	3903·63	96½	7313·84	122½	11785·90	148½	17319·83
44½	1555·28	71	3959·20	97	7389·82	123	11882·31	149	17436·66
45	1590·43	71½	4015·16	97½	7466·20	123½	11979·11	149½	17553·88
45½	1625·97	72	4071·51	98	7542·98	124	12076·31	150	17671·50
46	1661·90								

TABLE OF THE WEIGHTS OF GASHOLDERS,

In Pounds for every One-tenth of an inch Maximum Pressure, and from 20 to 200 Feet in Diameter

Diameter of Gasholder in Feet.	Weight in lbs. for each One-tenth of an Inch Pressure.	Diameter of Gasholder in Feet.	Weight in lbs. for each One-tenth of an Inch Pressure.	Diameter of Gasholder in Feet.	Weight in lbs. for each One-tenth of an Inch Pressure.	Diameter of Gasholder in Feet.	Weight in lbs. for each One-tenth of an Inch Pressure.
20	164	53	1149	86	3026	119	5793
21	181	54	1193	87	3097	120	5891
22	198	55	1238	88	3168	121	5990
23	217	56	1283	89	3241	122	6089
24	236	57	1329	90	3314	123	6189
25	256	58	1376	91	3388	124	6290
26	277	59	1424	92	3463	125	6392
27	298	60	1473	93	3538	126	6495
28	321	61	1522	94	3615	127	6598
29	344	62	1573	95	3692	128	6703
30	368	63	1624	96	3770	129	6808
31	393	64	1676	97	3849	130	6914
32	419	65	1729	98	3929	131	7021
33	446	66	1782	99	4010	132	7128
34	473	67	1837	100	4091	133	7237
35	501	68	1892	101	4173	134	7346
36	530	69	1948	102	4256	135	7456
37	560	70	2005	103	4340	136	7567
38	591	71	2062	104	4425	137	7678
39	622	72	2121	105	4510	138	7791
40	655	73	2180	106	4597	139	7904
41	688	74	2240	107	4684	140	8018
42	722	75	2301	108	4772	141	8133
43	757	76	2363	109	4861	142	8249
44	792	77	2426	110	4950	143	8366
45	828	78	2489	111	5041	144	8483
46	866	79	2553	112	5132	145	8601
47	904	80	2618	113	5224	146	8720
48	943	81	2684	114	5317	147	8840
49	982	82	2751	115	5410	148	8961
50	1023	83	2818	116	5505	149	9083
51	1064	84	2887	117	5600	150	9205
52	1106	85	2956	118	5696	200	16,364

To Ascertain the Weight of a Gasholder by the above Table, the Diameter and Maximum Pressure being known.

Rule.—Multiply the number of lbs. standing opposite to the diameter by the pressure in tenths of an inch.

Example.—What is the weight of a gasholder 78 feet in diameter, *giving a* maximum pressure of 32/10ths?

2489 × *32* = 79,648 lbs., weight of gasholder.

To Ascertain, by the preceding Table, the Pressure which a Gasholder will give, the Diameter and Weight being known.

RULE.—Divide the weight in lbs. of the gasholder by the weight given opposite to the diameter.

EXAMPLE.—What pressure will a gasholder give whose weight is 32,075 lbs., and diameter 56 feet?

$$32{,}075 \div 1283 = 25/10\text{ths, maximum pressure of gasholder.}$$

The figures given in the foregoing table are based on the weight of a cubic foot of water—viz., 62·5 lbs., a column of water 1/10th of an inch high, with an area of 1 square foot, being ·52083 lbs., or the 120th part.

Thus, if the area of the holder in feet (obtained by squaring the diameter and multiplying by ·7854) be multiplied by 62·5, the weight of a cubic foot of water in lbs., and divided by 120, the number of 10ths of an inch in a foot, the product will be the weight of the holder in lbs. for each 1/10th of an inch maximum pressure.

Or thus: The area of a circle is to the square of its diameter as ·7854 is to 1; hence the weight of a gasholder in lbs., to give 1/10th of an inch pressure, is to the square of its diameter in feet as ·52083 × ·7854 is to unity; or, which is the same thing, as ·4091 is to unity. So to ascertain the weight of a holder, say, 100 feet diameter, giving a maximum pressure of 35/10ths—

$$100^2 \times 35 \times {\cdot}4091 = 143{,}185\text{ lbs., weight of gasholder.}$$

DIMENSIONS OF THE PRINCIPAL MATERIALS IN GASHOLDERS IN ACTUAL WORKING.

Single Gasholder.

Diameter, 30 ft. Depth, 15 ft.

Roof sheets, No. 17 B. wire gauge.
Side sheets, No. 18 B. wire gauge.
Inlet and outlet pipes, 6 in. diam.

Single Gasholder.

Diameter, 35 ft. Depth, 12 ft.

Roof Sheets, No. 15, B. wire gauge.
Side sheets, No. 16 B. wire gauge.
Crown Plate, 3 ft. 6 in. diam., ⅜ thick.
4 main and 4 secondary bars, of 3 in. T-iron.
Top and bottom curbs, of 3 in. angle-iron.
4 columns, 13 ft. 6 in. long; diam. at base, 6 in.; at top, 5½ in.
4 holding-down bolts to each column, 4 ft. long, 1 in. round-iron.

Single Gasholder.

Diameter, 36 ft. Depth 12 ft.

Roof sheets, No. 17 B. wire gauge.
Side sheets, No. 18 B. wire gauge.

Single Gasholder.

Diameter, 40 ft. Depth, 15 ft.

Crown plate, 3 ft. 5 in. diam., ⅜ in. thick.
Roof sheets, No. 14 B. wire gauge.
Side sheets, top and bottom tiers, No. 14 B. wire gauge; all the the rest, No. 15 B. wire gauge.
Rivets for sheets, ¼ in. diam., 1 in. apart, centre to centre.
Rivets for top curb, ½ in. diam., 1½ in. apart, centre to centre.
Rivets for bottom curb, ½ in. diam., 6 in. apart, centre to centre.
Centre-pipe of cast-iron, 6 ft. long, 4 in. diam.
Truss cup, cast-iron, 2 ft. 6 in. diam.
12 main bars, T-iron, 2½ × 2½ × ⅜ in.
4 vertical stays, T-iron, 3 × 2½ × ⅜ in.
Top curb, angle-iron, 3 × 3 × ⅜ in.
Bottom curb, angle-iron, 3 × 3 × ⅜ in.
4 columns, 17 ft. long; diam. at base 9 in.; diam. at top, 7 in.
3 holding-down bolts to each column, 7 ft. long each, 1¼ in. diam.
Girders of T-iron, 3 × 4 × ½ in., trussed.
Balance-weights, 40 cwt.; ½ in. chains.

Single Gasholder.

Diameter, 44 ft. 6 in. Depth, 20 feet.

Rise of crown, 1 ft. 9 in.
Crown plate, 3 ft. 6 in. diam., ⅜ in. thick.
Roof sheets, inner and outer circles, No. 12 B. wire gauge; all the rest, No. 14.
Side sheets, top and bottom tiers, No. 12 B. wire gauge; the rest, No. 17.
Rivets for Nos. 12 and 14 sheets, 5-16ths in. diam.; for No. 16 sheets, ¼ in. diameter.
5 main and 5 secondary bearing bars, of T-iron, 3 × 3 × ⅜ in.
5 columns, 22 ft. long, 7 in. diam. at base, 5¾ diam. at top; metal 11-16ths thick.
4 holding-down bolts, 16 ft. long, 1¼ in. square-iron.

Single Gasholder.

Diameter, 50 ft. Depth, 20 ft.

Rise of crown, 12 in.
Roof sheets, No. 14 B. wire gauge.
Side sheets, No. 15 B. wire gauge.
Rivets, 1 in. apart, centres.

Top and bottom curbs, 3 in. angle-iron.
8 vertical bars.
8 columns, 26 ft. long, cast in two lengths each; 12 in. diam. at base, 6 in. diam. at top.
Inlet-pipe, 9 in. diam.
Outlet-pipe, 10 in. diam.

Single Gasholder.

Diameter, 50 ft. Depth, 16 ft.

Rise of crown, 2 ft. 6 in.
Crown plate, 3 ft. diam., ¼ in. thick.
Roof sheets, inner and outer circles, No. 12 B. wire gauge; all the others, No. 14.
Side sheets, top and bottom tiers, No. 14 B. wire gauge; the others, No. 16.
Rivets, ¼ in. diam., 1 in. apart, centres.
Rivets for joining sheets to angle-iron, ⅜ in. diam., 1½ in. apart centres.
Rivets for bottom curb, ½ in. diam., 9 in. apart, centres.
10 main, and 10 secondary rafters, of T-iron, 3 × 3 × ⅜ in.
Top curb, of angle-iron, 3 × 3 × ⅜ in.
Bottom curb, 2 rings of angle-iron, 3 × 3 × ⅜ in., 6 in. apart, with flat bar of iron, 6 in. wide and ½ in. thick, between them.
Centre strut, cast-iron pipe, 9 ft. long, 6 in. external diam., ¾ in. thick; bearing flanges, 13 in. diam., 1¼ in. thick; outer rim of cup strengthened by a ring of S C and crown-iron, 2 × 1 in., shrunk on hot.
10 vertical ribs, T-iron, 3 × 3 × ⅜ in., secured to top and bottom curbs and to side sheets.
5 columns, 18 ft. long; diam. at base, 7 in.; diameter at top, 5 in. metal ¾ in. thick.
Suspension chains, ½ in. short link, tested to 5 tons.

Single Gasholder.

Diameter, 50 ft. Depth, 18 ft.

Roof sheets, No. 14 B. wire gauge.
Side sheets, No. 15 B. wire gauge.
Inlet and outlet pipes, 9 in. diam.

Single Gasholder.

Diameter, 60 ft. Depth, 17 ft.

Rise of crown, 3 ft.
Crown plate, 4 ft. diam., ½ in. thick.
Roof sheets, inner and outer circles, No. 13 B. wire gauge; the rest, No. 14.
Side sheets, top and bottom tiers, No. 14 B. wire gauge; the rest No. 15.
Top curb, 4 × 4 × 7-16ths in. angle-iron.

Bottom curb, two bars of 3 × 3 × ⅜ in. angle-iron, placed back to back, and bar of flat-iron riveted to the bottom with ⅜ in. rivets.
16 vertical bars, 2½ × 2½ × ⅜ in. T-iron, riveted to top and bottom curbs and to side sheets.
8 columns, 18 ft. long; diam. at base, 6⅜ in.; at top, 5½ in.; metal, ⅜ in. thick.

Single Gasholder.

Diameter, 60 ft. Depth, 18 ft.

Roof sheets, inner and outer circles, No. 13 B. wire gauge; the others, No. 14.
Side sheets, top and bottom tiers, No. 14 B. wire gauge; the others, No. 15.
Top curb, 4 × 4 × ⅓ in. angle-iron.
Bottom curb, formed of two bars of angle-iron, 4 × 4 × ½ in., riveted back to back with ½ in. rivets 12 in. apart, centres.
14 vertical bars, 4 × 3 × ½ in. T-iron.
7 columns, 19 ft. 6 in. long each.

Single Gasholder.

Diameter, 81 ft. 8 in. Depth, 20 ft. 6 in.

Rise of crown, 3 ft.
Crown plate, 4 ft. diam., ½ in. thick.
Roof sheets, inner and outer circles, No. 10; all the rest, No. 14 B. wire gauge.
Side sheets, top and bottom tiers, No. 14; all the rest, No. 16 B. wire gauge.
Rivets, ¼ in. diam., 1 in. apart, centres.
16 main rafters, 5 × 3 × ½ in. T-iron.
16 secondary rafters, 4 × ½ in. flat-iron, placed on edge.
Centre strut, cast-iron pipe, 9 ft. long, 7 in. external diam., 1 in. thick; flanges, 13 in. diam., 1½ in. thick; cup strengthened by a hoop 2 × 1 in. S C iron, shrunk on hot.
Tension rods, long Queen bolts, short Queen bolts, long suspenders short suspenders, 16 in number each, of 1¼ in., 1½ in., 1¼ in., 1 in., and ⅞ in. round-iron respectively.
Top curb, of angle-iron, double, 4 by 4 by ½ in.
Bottom curb, of angle-iron, 4 by 4 by ½ in., with bar of flat-iron, 6 by ½ in. beween, and riveted with ⅝ in. rivets 12 in. apart.
12 vertical bars, 4 × 3 × ½ in. T-iron.

Single Gasholder.

Diameter, 87 ft. Depth, 20 ft.

Rise of crown, 4 ft.
2 crown plates, 4 ft. diam., ½ in. thick.
Roof sheets, inner and outer circles, No. 12; the rest, No. 14 B. *wire gauge, except* 9 sheets upon which the sliding carriages are *fixed, No. 7 B.* wire gauge.

Side sheets, top and bottom tiers, No. 12; all the remainder, No. 14 B. wire gauge.
Rivets, 5-16ths in. diam., 1 in. apart centres.
Centre-pipe of wrought-iron, 12 ft. long, 12 in. diam.
Truss cup, wrought-iron, 3 ft. diam., ¾ in. thick.
18 main bars, T-iron, 4 × 3 × ½ in.
18 secondary bars, T-iron, 3 × 3 × ½ in.
9 rings or purlins of bracket bars, the middle purlin of angle-iron 3½ × 3½ × ½ in., the remainder of flat-iron 2 × ½ in., secured to main and secondary bars with ⅝ in. bolts.
18 principal tension rods, 1½ in. diam.
36 diagonal tension rods, ⅞ in. diam.
36 truss bars; 18 of 1½ in. diam., 18 of 1¼ in. diam.
Top curb, 2 rings of angle-iron, 3½ × 3½ × ⅜ in.
Bottom curb, 2 rings of angle-iron, 3½ × 3½ × ⅜ in.
18 vertical truss bars, T-iron, 3½ × 3½ × ½ in.
9 columns, 22 ft. long each, 14 in. diam. at base, 11 in. at top.
4 holding-down bolts, 8 ft. long, 1½ in. diam.

Single Gasholder.

Diameter, 100 ft. Depth, 20 ft.

Rise of crown, 5 ft.
2 crown plates 5 ft. diam., ⅝ in. thick.
Roof sheets, inner and outer circles, No. 10; the remainder, No. 12 B. wire gauge, except carriage sheets, ¼ in. thick.
Side sheets, top and bottom tiers, No. 9; the remainder, No. 12 B. wire gauge.
Rivets, 5-16th in. diam., 1 in. apart, centres.
Centre-pipe of wrought-iron, 14 ft. long, 24 in. diam., 5-16ths in. thick.
18 main and 18 secondary bars.
Top curb, 2 rings of angle iron, 4 × 4 × 7-16ths in.
Bottom curb, 2 rings of angle-iron, 4 × 4 × 7-16ths in., and a flat bar of wrought-iron 6 × ⅜ in.
18 vertical bars, T-iron, 4 × 4 × ⅜ in.
9 columns, 24 ft. long, 24 in. diam. at base, 18 in. diam. at top, 1¼ to 1 in. metal.
4 holding-down bolts, 8 feet long, 1½ in. diam.

Single Gasholder.

Diameter, 110 ft. Depth, 26 ft.

Rise of crown, 5 ft. 6 in.
Crown plates, 4 ft. diam.; ½ in. thick.
Roof sheets, row next centre and outer row next curb, ¼ in. thick; second row from centre, ⅛ in. thick; and second row next curb, 3-16ths in. thick; the remainder No. 12 B. wire gauge.
Side sheets, top and bottom rows, ½ in. thick; next row to each 3-16ths in. thick; the remainder No. 12 B. wire gauge.
Rivets, ¼ in. and 3-16ths in. plates ⅜ in. rivets, 2 in. centres; the ⅛ in. and No. 12 B. wire gauge sheets 5-16ths in. rivets, 1¼ in. centres; ¼ *in. plates* and curb ⅝ in. rivets, 2 in. centres.

Top curb of 2 angle-irons 5 × 4 × ½ in.
Bottom curb of 2 angle-irons 4 × 4 × ½ in.
Vertical stays, 14, of 2 angle-irons 3 × 3 × ½ in., and a piece of timber 12 in. × 4 in. bolted between.
Centre pipe of ¼ in. plate, 2 ft. diam.
Main rafters, 28, of T-iron 5 × 3 × ½ in.
Purlins, of T-iron 3 × 4 × ½ in., and remainder of angle-iron 3 × 3 × ⅜ in.
Struts, 3, on main rafters 1½ and 1¼ in. diam.
Tie rod, principal 1⅝ in. diam., second 1½ in. diam., and third 1 in. diam.
Columns, 14, of cast-iron 1 ft. 6 in. diam. at bottom, 1 ft. 2 in. at top; metal ⅞ in. at bottom, diminishing to ⅝ in. thick at top.
Holding down bolts, 4, 1½ in. diam., 20 ft. long.
Lattice girders, 14, 1 ft. 6 in. deep, of two frames of angle-iron, 3 × 3 × ½ in., and braces 2½ × ¼ inch riveted between, top and bottom of girder covered with a plate 10 in. wide by ⅜ in. thick.

Single Gasholder.

Diameter, 142 ft. Depth, 55 ft.

Roof, without trussing or framework.
Roof sheets, first, or outside circle, 3 ft. long, ⅜ in. thick; rivets ⅝ in. diam., 2½ in. apart, centres. Second circle, 3 ft. long, ¼ in. thick; rivets, 9-16ths diam., 2½ in. apart, centres; centre sheets, forming a circle 30 ft. diam., ¼ in. thick, butted and riveted to each other by lapping pieces, 3½ in. wide; rivets, 9-16ths in. diam.; remainder of roof sheets, 5 ft. long, 3-16ths in. (No. 7 B. wire gauge) thick; rivets, ⅜ in. diam., 1¼ in. apart, centres.
Side sheets, top and bottom tiers, ¼ in. thick; rivets, ½ in. diam., 1½ in. apart, centres. Intervening side sheets, No. 10 B. wire gauge; rivets, ⅜ in. diam., 1¼ in. apart, centres.
Top curb, a circular chamber or girder, in section nearly rectangular, outer depth, 18 in.; inner depth, 19¼ in.; width, 2 ft. 6 in.; constructed of 4 × 4 × ½ in. angle-iron.
Bottom curb, formed of two circles of ⅜ in. boiler-plates, 12 in. wide, each riveted to a circle of angle-iron, 4 × 4 × ½ in.
32 vertical stays, 3 sides of a rectangular figure, 12 in. wide, 10 in. deep; formed of 4 angle-irons 3 × 3 × ⅜ in. and ¼ in. boiler-plate.
16 columns, diam. at base 3 ft.; at top, 2 ft. 3 in.; metal ⅞ in. to ¾ in. thick.
holding-down bolts, 10 ft. long, 2¼ in. round-iron.

Two-lift Telescopic Gasholder.

Diameter of outer lift, 44½ ft. Depth, 16 ft.

Diameter of inner lift, 43 ft. Depth, 16 ft.

Rise of crown, 1 ft. 9 in.
Crown plate, 3 ft. 6 in. diam., ⅜ in. thick.
Roof sheets, inner and outer circles, No. 12; all the rest, No. 14 B. *wire gauge.*

Side sheets in both lifts, top and bottom tiers, No. 12; all the rest, No. 16 B. wire gauge.
Rivets for Nos. 12 and 14 sheets, 5-16ths in. diam.; for No. 16 sheets, ¼ in. diam.
Cup, inner lift, formed by 2 rings of 2½ × 2½ × 5-16ths in. angle-iron, connected together with No. 8 plates, with side of No. 10 plate, and a ring 1½ × ½ in. half-round iron, riveted round.
Dip, outer lift, the counterpart of the cup, inverted.
Main-bearing bars, T-iron, 3 × 3 × ½ in.
Secondary bearing bars, T-iron, 3 × 3 × ⅜ in.
6 vertical bars, inner lift, T-iron, 2½ × 2½ × ⅜ in.
6 vertical bars, outer lift, T-iron, 2½ × 1½ × ⅜ in.
Bottom curb, angle-iron, double, 3 × 3 × ⅜ in.
6 columns, 12 in. diam. at base, 10 in. at top; metal 1 in. to ¾ in. thick.

Two-lift Telescopic Gasholder.

Diameter, outer lift, 87 ft. Depth, 20 ft.

Diameter, outer lift, 85 ft. Depth, 20½ ft.

Rise of crown, 4 ft.
2 crown plates, 4 ft. diam., ½ in. thick.
Roof sheets, inner and outer circles, No. 12; the rest, No. 14 B. wire gauge, except 9 sheets upon which the carriages are fixed, No. 7 B. wire gauge.
Side sheets, top and bottom tiers, both lifts, No. 12; all the rest, No. 14 B. wire gauge.
Rivets, 5-16ths in. diam., 1 in. apart, centres.
Hydraulic cup and dip, 7 in. wide, 16 in. deep.
Centre-pipe of wrought-iron, 12 ft. long, 12 in. diam.
Truss cup, wrought-iron, 3 ft. diam., ¾ in. thick.
18 main bars, T-iron, 4 × 3 × ½ in.
18 secondary bars, T-iron, 3 × 3 × ½ in.
9 rings or purlins of bracket bars, the middle purlin of angle-iron, 3½ × 3½ × ½ in., the remainder of flat-iron 2 × ½ in., secured to main and secondary bars with ⅝ in. bolts.
18 principal tension rods; 1¼ in. diam.
36 diagonal tension rods, ⅞ in. diam.
36 truss bars; 18 of 1½ in. diam., 18 of 1¼ in. diam.
Bottom curb, 2 rings of angle-iron, 3½ × 3½ × ⅜ in.
18 vertical truss bars, T-iron, 3½ × 3½ × ½ in.
9 columns, 41 ft. long, 30 in. diam. at base, 20 in. at top, 1⅛ to ⅞ in. metal, cast in 4 lengths.
4 holding-down bolts, 8 ft. long, 1½ in. diam.

Two-lift Telescopic Gasholder.

Diameter, outer lift, 100 ft. Depth, 22 ft.

Diameter, inner lift, 98 ft. Depth, 22 ft.

Roof sheets, No. 11 B. wire gauge.
Side sheets, top tier, No. 11; all the others, No. 12 B. wire gauge.
Rivets, ¼ in. diam., 1 in. apart, centres.

Hydraulic joint, 8 in. wide, 15 in. deep, No. 10 B. wire gauge; top edge of cup and bottom edge of dip bound by half-round iron, 2 × 1 in. thick.
Bottom curb, angle-iron, 4 × 1 in. at the root, and ring of bar-iron 4 × 1 in.
12 columns, 24 in. diam. at base, 16 in. at top; metal 1⅛ to 1 in. thick.
4 holding-down bolts, 10 ft. long, 2 in. square-iron.

Two-lift Telescopic Gasholder.

Diameter, outer lift, 102 ft. Depth, 22 ft.

Diameter, inner lift, 100 ft. Depth, 22½ ft.

Rise of crown, 4 ft.
Crown plate, 5 ft. diam., ⅝ in. thick.
Roof sheets, first ring next centre, No. 9; next and outer rings, No. 11; all the rest, No. 12 B. wire gauge.
Side sheets, outer lift, top and bottom tiers, No. 11; all the rest, No. 13 B. wire gauge. Inner lift, top and bottom tiers, No. 13; all the rest, No. 17 B. wire gauge.
Cup and dip, 8 in. wide, 15 in. deep, of angle-iron 3 × 3 × ⅜ in.; plate, No. 7 B. wire gauge; edges stiffened with 1½ × ¾ in. half-round-iron; ½ in. rivets, 6 in. apart.
10 columns, 18 in. diam. at base, 14 in. at top; metal, 1½ to ¾ in. thick, cast in 4 lengths.
4 holding-down bolts, 8 ft. long, 2 in. square, wrought-iron.

Two-lift Telescopic Gasholder.

Diameter, outer lift, 103 ft. Depth, 25½ ft.

Diameter, inner lift, 101 ft. Depth, 24 ft.

2 crown plates, 4 ft. diam., ½ in thick.
Roof sheets, inner and outer rings, ⅛ in. thick; all the rest, 1-10th in. thick.
Side sheets, top and bottom tiers, ⅛ in. thick; the remainder, 1-10th in. thick.

Two-Lift Telescopic Gasholder.

Diameter, outer lift, 112 ft. Depth, 26 ft.

Diameter, inner lift, 110 ft. Depth, 26 ft.

Rise of crown, 6 ft.
Roof, trussed.
Roof sheets, centre plate ½ inch thick, next row ¼ in.; next, 3-16ths *in.; outer* row, ¼ in.; next, 3-16ths in.; and the intermediate *7 rows ⅛ in.* thick.

Side sheets, 3-16ths in. thick top and bottom rows, remainder No. 12 B. wire gauge; the cup, 8 in. × 18 in., is formed of 2 rings of 3 × 3 × ⅜ in. angle-iron, the bottom and sides being of ¼ in. plate, having 2 and 1 in. half-round bead at edge of plate.

Top curb, of two rings of angle-iron 5 × 3½ × ½ in.

Bottom curb, of 2 rings of angle-iron 5 × 3 × ½ in. placed 9 in. apart, between which the bottom roller carriages are secured.

Vertical stays, inner lift, 28, 14 of which are of 2 angle-irons 3 × 3 × ½ in. riveted on each side to a web plate 9 in. wide and ½ in. thick; the remaining 14 being of T-iron 5 × 3 × ½ in. trussed with three struts and a tie rod. Outer lift has 28 vertical stays of ⅜ in. guard-iron 5 in. wide, against which the guide pieces on the cup slide.

Centre column, 17 ft. 6 in. long and 2 ft. diam. of wrought-iron plates ⅜ in. thick, ¾ in. rivets, 2½ in. pitch; this is secured to the under crown plate, which is 4 ft. in diam., by a ring of angle-iron 5 × 4 × ½ in., and ¾ in. rivets; at the lower end of the column are 2 rings of angle-iron, 5 × 4 × ¾ in., placed 3½ in. apart to form a jaw to receive ends of tension rods.

Main rafters, 14, of T-iron, 4 × 5 × ½ in. trussed with six wrought-iron struts 1¼, 1½, and 1¾ in. diam. and a 1½ in. diam. tension rod. Fourteen main tie rods of 1¾ in. round-iron, extending from curb to bottom of centre column, and suspended in two places from the main rafters with ½ inch round rods; the main tie rods and the tension rods have each a wrought-iron coupling box with right and left hand threads.

Secondary rafters, 14, T-iron, 3 × 5 × ½ in. trussed as above with four struts 1¼ and 1½ in. diam., tension rod 1¼ in. diam., with coupling box; these rafters extend from curb to within 21 ft. of the centre of holder, the inner ends being secured to a main brace bar or purlin.

Purlins, 7 rows between side and centre, the main purlin mentioned above is 4½ × 4½ × 9-16ths in., the one next curb 4 × 3 × ½ in., and the remainder 3 × 3 × ⅜ in. all of T-iron.

Columns, 14, of cast-iron, 2 ft. 6 in. diameter at bottom, 2 ft at top, and 55 ft. 8 in. high, surmounted with a large ball 30 in. diam., with spiked finial.

Girders, 2 rows, each 2 ft. deep, and 10 in. wide, of 4 angle-irons 3 × 3 × ⅜ in., with plate 10 × ⅜ in. top and bottom, diagonal braces 3 × ⅜ in., at the intersection of which is a cast-iron spiked ball in two halves, 17 in. diam. across spikes.

Holding-down bolts, 4, 2 in. diam., 11 ft. 6 in. long.

Two-lift Telescopic Gasholder.

Diameter, outer lift, 120 ft. Depth, 24 ft.

Diameter, inner lift, 118 ft. Depth, 24 ft.

Rise of crown, 6 ft.

Roof, untrussed, resting when down on timber framing in tank.

Roof sheets, first or outside row, ⅜ in. thick; second row, ¼ in.; third row, 3-16ths in.; fourth row, No. 8 B. wire gauge; crown plates, ¼ in. thick and 6 ft. in diam.; inside row, next crown plate, 3-16ths in.; next, No. 8 B. wire gauge; and the remaining 10 rows of intermediate sheets No. 11 B. wire gauge.

Side sheets, inner lift, 12 courses high; top and bottom course ¼ in. thick; second course at top, 3-16ths in.; and the remainder No. 12 B. wire gauge.

Side sheets, outer lift, 12 courses high; top and bottom course, ¼ in. thick; second course at bottom, 3-16ths in.; and the remainder No. 12 B. wire gauge. The thicker sheets in both inner and outer lift riveted together with ⅜ in. rivets, 1¼ in. apart centres, and the others with 5-16ths in. rivets, 1⅛ in. apart centres.

Top curb, of 2 angle-irons, one at junction of roof with side sheets 5 × 5 × ⅝ in., and the other at the inner edge of outer row of sheets, 4 × 4 × ½ in.; the two stiffened by gusset pieces springing from the vertical stays.

Bottom curb, of two 5 × 4 × ⅝ in. angle-irons, riveted to the outside of the lower row of sheets, with ⅜ in. rivets, 6 in. apart. Between these two curbs, which are placed 2 in. apart, are fixed the 28 guide carriages and rollers.

Cups, formed rolled channel-iron 8 × 3½ × ½ in., riveted to the side sheets and rising plates, with ½ in. rivets 4 in. apart. A half-round bead 2 × ⅜ in. being riveted to edge of rising plates, which are ⅜ in. thick and 18 in. deep.

Vertical stays, 28, formed of two 4 × 4 × ½ in. angle-irons and a web-plate between, ⅜ in. thick and 9 in. wide, secured with ¾ in. rivets 6 in. apart; at the upper end of these is attached a gusset-plate with angle-iron edges 3 × 3 × ⅜ in. extending to the inner angle-iron curb of roof, to which and the outer curb it is riveted.

Standards 14, in the form of the letter T, 4 ft. 2 in. × 3 ft. at bottom, tapering to 1 ft. 9 in. each way at the top; each standard 51 ft. high. Between the angle-iron framework of the standards is cast-iron trellis work, 1 in. thick on one of its sides, and wrought-iron lattice work on the other; the standards are secured to cast-iron hollow base plates 6 in. deep; 4 holding bolts to each standard, 11 ft. 6 in. long, 2¼ in. diam.

Lattice girders, 2 rows in the height; first or lower row, 27 in. deep; top row, 30 in. deep; formed of 4 angle-irons 3 × 3 × ½ in. wrought-iron tension bars 3 × ½-inch and cast-iron struts.

Two-lift Telescopic Gasholder.

Diameter, outer lift, 151 ft. 6 in. Depth, 40 ft.

Diameter, inner lift, 149 ft. Depth, 40 ft. 3 in.

Crown trussed, rise 8 ft.

Roof sheets, outer row, 5-16ths in.; next row, 3-16ths in.; and the remainder No. 10 B. wire gauge, two centre plates ¾ in. thick and 4 ft. 6 in. diam.

Side sheets, top and bottom rows in both lifts ¼ in. thick, the remainder No. 11 B. wire gauge, ¼ in. rivets 1 in. centre; cup and grip 10 in. wide and 20 in. deep, Piggot's form; plates ⅜ in. thick, strengthened at edges with bead-iron.

Top curb, of 2 rings of angle-iron 5 × 5 × ½ in., placed one above the other; the lower one is secured to a flat bar 10 in. wide and ½ in. thick, which is again connected by straps 4 in. wide and ½ in. *thick to the top* row of sheets.

Bottom curb, of 2 rings of angle-iron 5 × 4 × ⅝ in. riveted to the outside of the bottom row of sheets with ⅝ in. rivets; between these two rings are fixed the bottom guide roller carriages.

Vertical stays, 32 in. top lift of H-iron 12 in. deep, and 32 in. bottom lift, of channel-iron 8 × 2½ × ½ in., attached to sheets, cups, and curbs with ⅝ in. bolts in upper lift, and ⅝ in. screwed pins in lower lift.

Centre column, 3 ft. 6 in. diam., 22 ft. long, of plates 7-16ths in. thick.

Roof framing, 24 main radial T-iron bars 6 × 4 × ½ in. curved to roof, each with a main tension rod 2 in. in diam. at curb, and reduced to 1½ in. at the foot of centre column, and having a coupling box with right and left hand thread, 4 struts and 4 tension rods form the bracing to this main bar, the former of cross-iron 4 × 4½ × ¾ in. placed vertically, and the latter of 1, 1⅛, 1¼, and 1⅜ in. round-iron placed diagonally, the strongest section being nearest the centre column; 48 secondary radial bars of 4 × ½ in. flat-iron, that is, 2 equidistant between each main radial bar, and extending from top curb towards centre a distance of 26 ft., and then for a further distance of 16 ft., in direction of the centre, another bar of the same dimensions is fixed. 17 rings or rows of purlins, divided equally from curb to centre, are fixed between main and secondary bars; the first row from centre being of 6 × ½ in. flat-iron; next 4 rows of angle-iron, 1½ × 1½ × ¼ in.; next row of angle-iron 2 × 2 × ¼ in.; next row of T-iron 3 × 6 × ½ in.; next 2 rows, which are subdivided in length by the secondary radial bar above mentioned, are of angle-iron 1½ × 1½ × ¼ in.; next row extending from main bar to main bar is of I-iron 3 × 6 × ½ in.; next 2 rows are divided in 3 lengths between main bars by the two secondary bars, and are of 1½ × 1½ × ¼ in. angle-iron; next row extending from main to main is of T-iron 4 × 6 × ½ in.; next row divided in 3 lengths as before of 1½ × 1½ × ¼ in. angle-iron, and the remaining 2 rows divided in 3 as before of 2 × 2 × ¼ in. angle-iron; 3 bars of flat-iron 2½ × ⅜ in. cross diagonally in each bay formed by the two main bars.

Columns, 16, of cast-iron, 83 ft. high, 3 ft. in diam. at base and 2 ft. 8 in. at top, metal 1 in. thick; cast-iron channel guide up the column, 5 × 3 in. inside measure, weighing 56 lbs. per foot.

Girders, 16, at top 4 ft. deep, 7 in. wide, of 4 angle-iron 3 × 3 × ⅜ in. and a top and bottom plate 7 in. wide by ⅜ in. thick; diagonal brace bars 4 × ⅜ in.; 16 intermediate girders 3 ft. 6 in. deep, 6 in. wide, of 4 angle-irons 2½ × 2½ × ⅜ in., and top and bottom plates 6 in. wide by ⅜ in. thick, diagonal brace bars 3 × ⅜ in.; at the intersection of the brace bars a cast-iron star 12 in. in diam. is riveted.

Holding-down bolts, 4, 2 in. square and 14 ft. long.

Capacity, 1,400,000 cubic feet.

Two-lift Telescopic Gasholder.

Diameter, outer lift, 197 ft. 6 in. Depth, 36 ft.

Diameter, inner lift, 195 ft. Depth, 36 ft.

Crown, untrussed, rise 10 ft.

Roof sheets, centre plate ¼ in. thick, 6 ft. diameter; row next

6 × 3 × ½ in. angle-steel, all riveted together with ⅞ in. and 1 in. steel rivets, 4 in. pitch.

Bottom curb, formed by a plate ⅝ in. thick, and 15 in. wide, secured at right angles to the lower rows of sheets to a 6 × 3 × ½ in. angle-iron with ¾ in. rivets, 5½ in. pitch; another angle-iron of the same dimensions being placed 1 ft. 5 in. higher, forming a space in which are fixed the bottom roller carriages.

Vertical stays, 48, on lower and middle lifts are made of No. 10 B. wire gauge sheets bent in the form thus 8 × 4½ in., riveted to the outside of the sheets, and on the inside opposite these are 8 × 3½ × ½ in. channel-irons, placed between two 4 × 3 × ½ in. angle-irons, which are riveted through the sheets to the outside stays. The top or inner lift is stiffened by No. 8 B. wire gauge sheets of the same form as above, but are 12 × 9 in., placed inside only.

Standards, 24, in the form of the letter H, 20 × 16 in. and 158 ft. 6 in. high above coping of tank, of wrought-iron formed of four 3 × 3 × ⅜ in. angle-irons ⅜ in. web plate, and ½ in. inside and outside plates, having 5 tiers of struts from standard to standard, and 10 sets of diagonal braces. Two channel-irons 8 × 3 × ½ in. riveted to each other back to back and to the standards form the guides upon which the radial and tangential rollers work; the bottoms of standards are fastened to triangular shaped cast-iron base-plates, each secured to the tank with three 2½ in. bolts.

Capacity, 5½ million cubic feet.

THE GOVERNOR.

An unnecessarily high pressure of gas in the mains and service-pipes is synonymous with a heavy leakage account.

Ordinary valves are powerless to effect the desired pressure regulation, however well they may be attended to. No gas-works, therefore, whatever its size, should be without a governor to control the initial pressure.

When properly constructed it accomplishes this important object perfectly, however much the consumption on the one side and the density of the gas on the other may vary.

The construction of the governor is of the most simple character, consisting of small cast-iron water-tank, through the bottom of which the gas from the regular holder enters and makes its exit by means of a stand-pipe rising above the water level. This pipe may be either annular or rectangular in form. In the former case the gas enters by way of the central opening, and makes its exit by the annular space. In the latter arrangement the pipe is divided in two by a mid-feather, one division being the inlet and the other the outlet for the gas; the inlet division of the pipe occupying the central position in the tank. Within the tank is a floating bell or gasholder made of tinned sheet-iron, from the crown of which a conical or parabolic shaped valve is suspended by an eye-bolt. It is the raising and depressing of this valve within the inlet gas aperture, by reason of the gas pressing on the inner surface of the floating bell, that accomplishes the necessary regulation.

The holder may be balanced or buoyed up either by means of an air nber within itself, placed round its lower curb, and consequently ıersed in the water of the tank, or by a chain secured to its crown ide, passing over one or two pulleys, and terminating in a rod carg the required balance weights, the needed pressure being obtained lacing cast-iron or lead weights on the crown of the holder; or it be weighted with water allowed to flow from a feed pipe into a : formed by continuing the sides of the holder a few inches above crown. The method of weighting by water is preferable to the r, as the pressure can be applied or removed in a more gradual ner, the opening in the supply and discharge taps being regulated ısired.

ıe conical valve for increasing or diminishing the area of the gas ture has generally given place to that in the form of a parabola; latter requiring a shorter range to produce the necessary effect, being more delicate and certain in its action. The parabola should ıade twice its diameter in length, and of weight sufficient to resist, out oscillation or blinking, whatever pressure may be exerted ıst it by the inflowing gas. With the like object it was formerly ssary to make the floating bell with an area 20 times greater than ırea of the base of the valve; but with the improvements effected overnors this is not now required, and much less space is now pied by the instrument.

rious accidents have arisen from the escape of gas by the tilting of loating bell; and, to obviate this danger, improvements have been ›duced in the construction of governors.

ıe governor of Messrs. J. and J. Braddock (Fig. 62 in section) will 7 what has been done in this direction. The gas enters from above the valve chamber. Over the valve, and of the same area as its base, is a compensating chamber within the bell, which is supplied with gas through a small pipe enclosing the valve rod, so placing the bell and valve in equilibrium. The bell is actuated by the outlet pressure, through a small pipe attached to the outlet branch. It will thus be seen that if by accident the bell were tilted or rent, the quantity of gas escaping would be limited to what would be discharged through the two small pipes referred to.

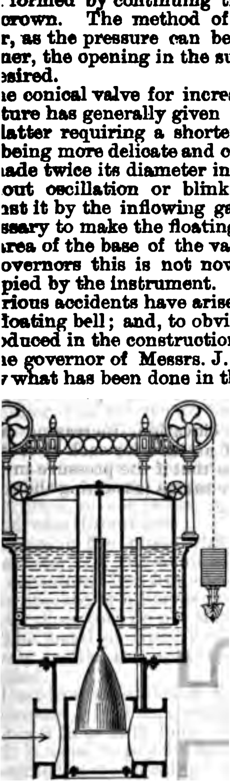


FIG. 62.

Mr. F. W. Hartley introduces a safety and regulating plate over the valve to effect the same object, and he obtains compensation by means of a small tank and holder placed alongside the governor, the holder being suspended from the chain carrying the counterpoise weights.

Mr. D. Bruce Peebles employs the pressure of the inlet gas, supplied through a small pipe having a dry regulator fixed ı it, to load the bell of the governor, which is enclosed in a gast case; and the only adjustment required is by means of small ;hts to the regulator.

r. W. Cowan has introduced various improvements in governors, 'hich the adjusted pressure is maintained under all variations of ght or changes at the inlet. Mr. Cowan has also invented an

"Automatic Pressure Changer," a most ingenious instrument for raising and reducing the pressure automatically at any given time, thus dispensing with the attendant, except on extraordinary occasions.

Mr. C. Hunt has adapted the ordinary throttle-valve to the purpose of a governor. By his plan a holder scarcely larger in diameter than the main only is required. Within the supply-main leading from the works to the street, the disc or throttle is accurately balanced on two small steel centres; the lever or radius arm by which it is actuated, being also inside the main, is attached to the centre of the disc. A small vertical pipe, communicating the holder with the main, serves to enclose the connecting- pipe attached to the radius arm and to the crown of the holder, and also conveys the gas into the latter. By means of this arrangement, a holder only 12½ inches in diameter will actuate an 8-inch valve; and one only 17 inches diameter, an 18-inch valve.

In winter time the water in a governor tank is liable to freeze, particularly if the house containing it is in an exposed situation. A very efficient and simple remedy for this is provided by the steam stove. This is merely a cast-iron cylinder or pipe, in the form of a pedestal, 2 ft. 6 in. to 3 ft. in height, and 10 or 12 in. in diameter, having a base, and an ornamental top or covering brightened by being ground and polished. The stove is placed on end on the floor of the governor room, in any convenient part, and a steam-pipe about 1 inch in diameter, with stop-cock, leading from the boiler, is inserted through the bottom, in which is another stop-cock for letting off the water of condensation. In time of frost, by means of this stove, the atmosphere of the room can be maintained at an equable temperature, at a minimum expense. A piece of ordinary cast-iron pipe can be adapted to the purpose; on the other hand, the stove is susceptible of any amount of ornamentation.

Gas pressure varies according to the elevation, increasing and decreasing at the rate of about one-tenth of an inch for each 10 feet of rise and fall respectively. It is thus obvious that if the pressure in the lower mains is sufficient, that in the higher mains (assuming them to be connected throughout) must be in excess.

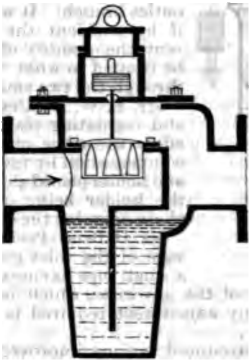


FIG. 63.

For the supply of gas to varying levels, therefore, separate leading mains, with a station governor upon each, are highly advantageous, and should be employed wherever practicable.

District or differential governors for the automatic regulation of the pressure in the mains at high altitudes considerably removed from the gas works are also of the utmost utility. These are produced both in the wet and dry form by most makers of gas apparatus. Fig. 68 shows the district governor made by Messrs. D. Bruce Peebles and Co.

By doubling the amount of pressure, the consumption of gas is increased by about one-half. Leakage from a pipe is of course increased in the same ratio, *i.e.* in the proportion of the square root of the pressure.

MAIN PIPES.

The leakage which arises in the distribution of gas, is largely due to defective and badly jointed main pipes.

Hence it is of the first importance to ensure that the pipes employed for that purpose are made of a good quality of metal, close in texture, free from defects of every kind, and as equal as possible in their sectional thickness.

To secure these three latter conditions, all pipes 5 inches internal diameter and upwards should be cast vertically in dry sand moulds. Smaller sizes are usually cast in green sand in inclined moulds.

The pipes should be tested by hydrostatic pressure equal to at least 75 lbs. on the square inch (150 feet head of water), either at the place of manufacture or on the gas works; and whilst under pressure they should be smartly rapped with a 4 lb. hammer from end to end. This will often reveal faults, such as sandy, porous, and blown places, not otherwise discernible.

Rapping the pipes whilst on the ground will also indicate their character. If the sound emitted is clear and bell like, the pipe may be considered free from defects. On the other hand, if dull and leaden, it is cracked or otherwise imperfect.

All pipes that do not stand the tests should be rejected.

The metal of pipes, whilst compact and close, should not be excessively brittle and splintry, but such as may be readily chipped and drilled.

Cast-iron pipes below 3 in. diameter are 6 ft. long; 3 in. to 11 in. diameter, 9 ft. long; when 12 in. diameter and upwards they may be either 9 ft. or 12 ft. long. The socket is not included in these lengths.

It is usual to pay for any overweight in the pipes beyond the weight specified, not exceeding 4 per cent.

Formula for calculating the weight of cast-iron pipes:—

$$W = 2{\cdot}45\ (D^2 - d^2).$$

Where D = outside diameter of pipe in inches.
d = inside diameter of pipe in inches.
W = weight of a lineal foot of pipe in lbs.

TABLE.

CAST-IRON GAS PIPES, WITH OPEN JOINTS.

The weight of the socket, and bead on spigot, is equal to 9-10ths of a lineal foot of the pipe, and this is included in the weights given.

Internal Diameter of Pipe.	Thickness of Metal in Body of Pipe.	Length of Socket, inside measure.	Length of Pipe, not including Socket.	Weight per Pipe, inclusive of Socket and Bead.		
Inches.	Inches.	Inches.	Feet.	Cwts.	qrs.	lbs.
1	5-16ths	2½	6	0	1	0
1½	5-16ths	2½	6	0	1	10
2	5-16ths	3	6	0	1	22
2½	3-8ths	3	6	0	2	17
3	3-8ths	3	9	1	0	11
4	3-8ths	4	9	1	1	19
5	7-16ths	4	9	2	0	7
6	7-16ths	4	9	2	1	21
7	5-10ths	4	9	3	0	27
8	5-10ths	4	9	3	2	19
9	5-10ths	4½	9	4	0	11
10	9-16ths	4½	9	5	0	16
11	9-16ths	4½	9	5	2	14
12	5-8ths	4½	12	8	3	16
13	5-8ths	4½	12	9	2	12
14	5-8ths	4½	12	10	1	8
15	5-8ths	4½	12	11	0	4
16	11-16ths	4½	12	12	3	24
17	11-16ths	4½	12	13	2	24
18	11-16ths	4½	12	14	2	0
19	3-4ths	4½	12	16	2	24
20	3-4ths	4½	12	17	2	8
21	3-4ths	5	12	18	1	20
22	13-16ths	5	12	20	3	20
23	13-16ths	5	12	21	3	8
24	7-8ths	5	12	24	2	8
30	1	5	12	35	0	0
36	1⅛	6	12	47	0	16
42	1 3/16	6	12	57	3	16
48	1¼	6	12	69	2	0

For the smaller sizes of pipes up to 8 in. diameter, the open jointin space is ⅜ in., and for larger diameters ½ in. wide all round. Th following are the usual depths of the socket, inside measure, for th various sizes of open-jointed gas pipes, plugged with yarn and lead :—

Diameter.	Depth of Socket.
Up to 3 inches	3 inches.
4 to 8 ,,	4 ,,
9 to 20 ,,	4½ ,,
21 to 30 ,,	5 ,,
32 ,, and upwards	6 ,,

TABLE.

CAST-IRON GAS PIPES, WITH TURNED AND BORED JOINTS, HAVING A RECESS IN FRONT FOR LEAD.

The weight of the socket and thickened spigot is equal to $1\frac{1}{16}$ lineal foot of the pipe, and this is included in the weights given.

Internal Diameter of Pipe.	Thickness of Metal in Body of Pipe.	Length of Socket, inside measure.	Length of Pipe, not including Socket.	Weight per Pipe, inclusive of Socket and thickened spigot.		
Inches.	Inches.	Inches.	Feet.	Cwts.	qrs.	lbs.
1	5-16ths	2½	6	0	1	1
1½	5-16ths	2½	6	0	1	12
2	5-16ths	3	6	0	1	24
2½	3-8ths	3	6	0	2	19
3	3-8ths	3½	9	1	0	14
4	3-8ths	4	9	1	1	22
5	7-16ths	4	9	2	0	18
6	7-16ths	4½	9	2	1	27
7	5-10ths	4½	9	3	1	8
8	5-10ths	4½	9	3	3	0
9	5-10ths	4½	9	4	0	23
10	9-16ths	4½	9	5	1	0
11	9-16ths	4½	9	5	3	1
12	5-8ths	4½	12	9	0	4
13	5-8ths	4½	12	9	3	0
14	5-8ths	4½	12	10	1	24
15	5-8ths	5	12	11	0	24
16	11-16ths	5	12	13	0	16
17	11-16ths	5½	12	13	3	20
18	11-16ths	5½	12	14	2	24
19	3-4ths	5½	12	16	3	24
20	3-4ths	5½	12	17	3	12
21	3-4ths	5½	12	18	2	24
22	13-16ths	5½	12	21	1	0
23	13-16ths	5½	12	22	0	20
24	7-8ths	5½	12	24	3	24
30	1	5½	12	35	2	4
36	1⅛th	6	12	47	3	16
42	$1\frac{3}{16}$th	6	12	58	3	4
48	1¼th	6	12	70	2	8

When the turned and bored joint, on being tested, is found gastight, it is not necessary to fill the recess with lead. The usual filling material adopted under such circumstances is Portland or Roman cement. These cements, if kneaded with warm water, set quickly; with cold water not so soon.

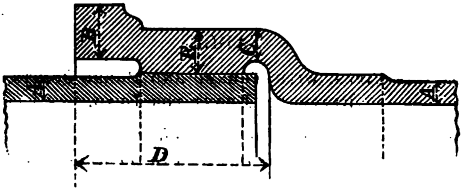


FIG. 64.

TABLE.

Dimensions of the Sockets of Turned and Bored Cast-Iron Gas Pipes, with a Recess in Front. (Fig. 64.)

Diameter of Pipe.	A	B	C	D	E
Inches.	Inches.	In.	In.	In.	In.
2	5-16ths	$\frac{13}{16}$	$\frac{1}{2}$	3	$\frac{3}{4}$
$2\frac{1}{2}$	3-8ths	$\frac{7}{8}$	$\frac{9}{16}$	$3\frac{1}{4}$	$\frac{13}{16}$
3	3-8ths	$\frac{15}{16}$	$\frac{5}{8}$	$3\frac{3}{4}$	$\frac{7}{8}$
$3\frac{1}{2}$	3-8ths	1	$\frac{5}{8}$	$3\frac{3}{4}$	$\frac{7}{8}$
4	3-8ths	$1\frac{1}{16}$	$\frac{11}{16}$	4	$\frac{15}{16}$
5	7-16ths	$1\frac{1}{8}$	$\frac{11}{16}$	4	$\frac{15}{16}$
6	7-16ths	$1\frac{1}{4}$	$\frac{3}{4}$	$4\frac{1}{2}$	1
7	5-10ths	$1\frac{5}{16}$	$\frac{3}{4}$	$4\frac{1}{2}$	1
8	5-10ths	$1\frac{3}{8}$	$\frac{13}{16}$	$4\frac{1}{2}$	$1\frac{1}{16}$
9	5-10ths	$1\frac{3}{8}$	$\frac{7}{8}$	$4\frac{1}{2}$	$1\frac{3}{16}$
10	9-16ths	$1\frac{7}{16}$	$\frac{7}{8}$	$4\frac{1}{2}$	$1\frac{3}{16}$
11	9-16ths	$1\frac{1}{2}$	$\frac{15}{16}$	$4\frac{1}{2}$	$1\frac{1}{4}$
12	5-8ths	$1\frac{1}{2}$	$\frac{15}{16}$	$4\frac{1}{2}$	$1\frac{1}{4}$
13	5-8ths	$1\frac{9}{16}$	$\frac{15}{16}$	$4\frac{1}{2}$	$1\frac{1}{4}$
14	5-8ths	$1\frac{9}{16}$	$\frac{15}{16}$	$4\frac{1}{2}$	$1\frac{1}{4}$
15	5-8ths	$1\frac{5}{8}$	1	5	$1\frac{5}{16}$
16	11-16ths	$1\frac{11}{16}$	1	5	$1\frac{5}{16}$
17	11-16ths	$1\frac{3}{4}$	$1\frac{1}{16}$	$5\frac{1}{4}$	$1\frac{3}{8}$
18	11-16ths	$1\frac{13}{16}$	$1\frac{1}{16}$	$5\frac{1}{4}$	$1\frac{3}{8}$
20	3-4ths	$1\frac{15}{16}$	$1\frac{1}{8}$	$5\frac{1}{4}$	$1\frac{7}{16}$

TABLE.

Dimensions of the Socke Turned and Bored Cast Gas Pipes without a Rec Front. (Fig. 65.)

Diam. of Pipe.	A	B	C
Inches.	Inches.	Inches.	Inches
2	5-16ths	$\frac{7}{8}$	$\frac{1}{2}$
$2\frac{1}{2}$	3-8ths	$\frac{15}{16}$	$\frac{9}{16}$
3	3-8ths	1	$\frac{5}{8}$
$3\frac{1}{2}$	3-8ths	$1\frac{1}{8}$	$\frac{5}{8}$
4	3-8ths	$1\frac{1}{4}$	$\frac{11}{16}$
5	7-16ths	$1\frac{3}{8}$	$\frac{11}{16}$
6	7-16ths	$1\frac{1}{2}$	$\frac{3}{4}$
7	5-10ths	$1\frac{9}{16}$	$\frac{3}{4}$
8	5-10ths	$1\frac{5}{8}$	$\frac{13}{16}$
9	5-10ths	$1\frac{11}{16}$	$\frac{7}{8}$
10	9-16ths	$1\frac{3}{4}$	$\frac{7}{8}$
11	9-16ths	$1\frac{13}{16}$	$\frac{15}{16}$
12	5-8ths	$1\frac{13}{16}$	$\frac{15}{16}$
13	5-8ths	$1\frac{7}{8}$	$\frac{15}{16}$
14	5-8ths	$1\frac{7}{8}$	$\frac{15}{16}$
15	5-8ths	2	1
16	11-16ths	2	1
17	11-16ths	$2\frac{1}{8}$	$1\frac{1}{16}$
18	11-16ths	$2\frac{1}{8}$	$1\frac{1}{16}$
20	3-4ths	$2\frac{1}{4}$	$1\frac{1}{8}$

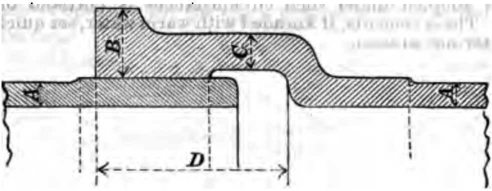


FIG. 65.

TABLE.

Cast-Iron Gas Pipes, with Flange Joints.

The weight of the flanges is equal to 1 lineal foot of the pipe, and this is included in the weights given.

Internal Diameter of Pipe.	Thickness of Metal in Body of Pipe.	Flanges. Diameter across Flanges.	Flanges. Thickness of Metal.	Flanges. Number of Bolt Holes.	Flanges. Diameter, centre to centre, of Bolt Holes.	Flanges. Diameter of Bolts.	Length of Pipe outside the Flanges.	Weight per Pipe, inclusive of the Flanges. Cwts.	qrs.	lbs.
Inches.	Inches.	Inches.	Inches.		Inches.	Inches.	Feet.	Cwts.	qrs.	lbs.
1	5-16ths	4	7/16	3	2⅞	5/16	6	0	1	0
1½	5-16ths	4½	7/16	3	3½	3/8	6	0	1	11
2	5-16ths	6¼	½	4	4¾	7/16	6	0	1	22
2½	3-8ths	7¼	9/16	4	5¼	½	6	0	2	18
3	3-8ths	7½	9/16	4	5½	½	9	1	0	11
4	3-8ths	9	9/16	4	7	½	9	1	1	22
5	7-16ths	10¼	⅝	4	8¼	⅝	9	2	0	10
6	7-16ths	11½	⅝	4	9½	⅝	9	2	1	24
7	5-10ths	13	¾	4	11	⅝	9	3	1	5
8	5-10ths	14½	¾	6	12	⅝	9	3	2	25
9	5-10ths	16	¾	6	13½	⅝	9	4	0	17
10	9-16ths	17¼	⅞	6	14¾	⅝	9	5	0	22
11	9-16ths	18¼	⅞	6	15¾	⅝	9	5	2	20
12	5-8ths	19½	15/16	6	16½	¾	12	8	3	24
13	5-8ths	20½	15/16	6	17½	¾	12	9	2	20
14	5-8ths	21½	1	8	18½	¾	12	10	1	16
15	5-8ths	22½	1	8	19½	¾	12	11	0	12
16	11-16ths	24	1 1/16	8	21	⅞	12	13	0	8
17	11-16ths	25	1 1/16	8	22	⅞	12	13	3	8
18	11-16ths	26	1⅛	10	23	⅞	12	14	2	12
19	3-4ths	27	1⅛	10	24	⅞	12	16	3	12
20	3-4ths	28	1⅛	10	24½	⅞	12	17	2	24
21	3-4ths	29	1⅛	10	25½	⅞	12	18	2	8
22	13-16ths	30	1 3/16	10	26½	⅞	12	21	0	8
23	13-16ths	31	1¼	10	27½	⅞	12	22	0	0
24	7-8ths	32	1 5/16	12	28½	⅞	12	24	3	0
30	1	38	1⅜	14	34½	1	12	35	1	0
36	1⅛	45	1⅜	18	41½	1	12	47	2	0
42	1 3/16	51	1½	20	47½	1	12	58	1	8
48	1¼	57	1¾	24	53½	1	12	70	0	4

Cast-iron in cooling shrinks one-eighth of an inch per foot.

Main Pipe Joints.

A host of joints for main pipes have been invented from time to time, which, though theoretically good, have not all proved very satisfactory in practice.

The classes of joint generally in use are the turned and bored, and the open joint. The ball and socket joint is employed under exceptional circumstances, as when the main has to be laid in the bed of a river or harbour, or across a narrow arm of the sea.

A difference of opinion exists amongst engineers as to which form of joint is best—the turned and bored, or the open joint filled with lead, rust cement, or other substance, metallic or otherwise.

We, who have had large experience in both, and under most circumstances, prefer the turned and bored, both for ease in adjustment, economy, and efficiency.

In districts, however, where the ground is extensively undermined and liable to subsidence, the vulcanized india-rubber joint (which is virtually an open joint) is the most suitable.

Special pipes, such as bends, tees, and junctions are, for convenience sake, made with open joints.

The turned and bored joint is shown in Fig. 66.

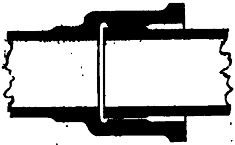


Fig. 66.

There is no difficulty in swinging round ordinary curves with a line of mains jointed in this manner; but when the radius of the curve is short, an occasional yarn and lead joint is required.

In specifying for pipes with these joints, care should be taken that the bored and turned surfaces are not made with too much taper; indeed, the nearer the surfaces approach to parallel lines the better they will fit.

When laying the pipes, the spigot and socket ends, after being cleaned with cotton waste, are coated with thick paint composed of one part each white and red lead mixed with boiled linseed oil; the end is then inserted, and driven home with a mallet, or should the pipe be large, with a swing block.

In driving the pipes, they will sometimes be found to spring back at every stroke. This may be due either to the surfaces being made too conical, in which case it will be difficult to ensure a good joint; or there is a slight ridge or roughness on the inner edge of the bored part of the socket. Chip this off with a sharp chisel.

Red lead sets sooner and harder than white, and the following reason is given for preferring the white to the red for joints:—When an expansion or contraction takes place in the pipes, the red lead is liable to crack, and so cause a leakage; whereas the white lead is more tractable, and better adapts itself to the varying circumstances. An equal mixture of the two is preferable.

The socket may either be bored flush up to the face, as in Fig. 65, or it may have a recess in front, as in Figs. 64 and 66. The latter is to be preferred, as it can be supplemented with lead or other filling should the turned joint proved defective.

Two examples of the open joint are given in Figs. 67 and 68.

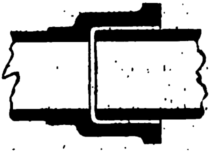


Fig. 67.

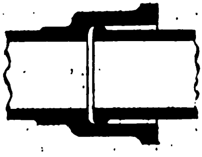


Fig. 68.

In placing the pipes, twined gasket is caulked in all round so as to fill nearly half the length of the open space. A roll of tough plastic clay is then passed round and pressed against the socket face, and through a lip on the upper side molten lead is poured till the remaining space is filled. On the lead being set up with a blunt caulking tool and hammer the joint is complete.

The ladle should contain sufficient molten lead to fill the joint at one pouring, otherwise the adhesion of the metal throughout will not be perfect.

Molten lead, when heated to redness, will fly when poured upon a wet or damp surface.

TABLE

Giving the Weight of Lead in pounds required for jointing Cast-Iron Mains.

Diameter of Pipe in Inches.	Depth of Lead in Inches.	Weight of Lead in Pounds.	Diameter of Pipe in Inches.	Depth of Lead in Inches.	Weight of Lead in Pounds.
1½	1⅜	1¼	11	2¼	16½
2	1½	1¾	12	2⅜	18½
2½	1⅝	2¼	13	2⅜	21
3	1⅝	2¾	14	2⅜	23½
4	1¾	4	15	2½	26
5	1⅞	5½	16	2½	28½
6	2	7	17	2½	31
7	2	8¾	18	2⅝	32½
8	2⅛	10½	19	2⅝	34
9	2⅛	12¼	20	2⅝	35½
10	2¼	14½	24	3	48

For pipes 1½ to 8 inches in diameter the lead is assumed to be about ⅜-inch thick; and in pipes 9 inches in diameter and upwards ½-inch thick. In place of lead, rust cement and a mixture of beeswax and tallow are used for jointing mains. "Spence's metal" also is an efficient substitute, and its cost is considerably less.

Iron or Rust Cements for Flange and Open Socket Joints.

1 lb. of clean iron borings, pounded fine in a mortar.
2 oz. sal ammoniac (muriate of ammonia) in powder.
1 oz. flowers of sulphur.

Mix the whole together by pounding, and keep dry. For use, mix one part with twenty of iron borings pounded, adding water to the consistence of mortar.

98 parts fine iron borings.
1 part flowers of sulphur.
1 part sal ammoniac.

Mix, and when required for use, dissolve in boiling water. This cement sets quickly.

If required to set slowly, which makes the better joint—

197 parts iron borings.
1 part flowers of sulphur.
2 parts sal ammoniac.

When required for use, mix with boiling water.

The iron borings used for making joints should be perfectly free from grease and oil.

The cubical content of the joint in inches, divided by 5, gives the weight in lbs. of iron cement required.

The india-rubber joint (Fig. 69) is formed by passing a vulcanized ring of that material round the spigot end of the pipe, which is specially cast with a groove and bead to suit this description of joint. When the pipe end is pushed forward into the socket, the ring is compressed or flattened, and butts against the raised bead. No other packing is necessary, so that it is an expeditious method of jointing, whilst the vulcanized india-rubber, unaffected by the presence of gas or moisture, is practically indestructible.

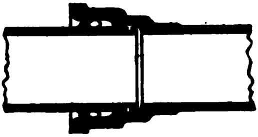


Fig. 69.

The other advantages of this joint are referred to above.

The ball and socket joint is shown in Fig. 70. This particular form is the invention of Mr. J. Z. Kay, and has been successfully employed for main pipes crossing through rivers and harbours where the ordinary rigid joint is inapplicable. The lead is first run in and caulked, and the connected pipes, being like a chain, can be paid out of a lighter, or other vessel, when they will find their own bed in the river bottom.

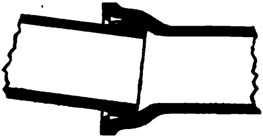


Fig. 70.

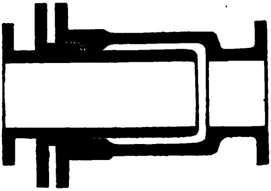


Fig. 71.

The expansion joint (Fig. 71) is useful in all cases where a line of main is exposed to varying temperatures, as in pipes placed against a wall or alongside a bridge, or in an open trench or channel.

Millboard or engine board, steeped for a few seconds in warm water to render it pliable, and coated with red or white lead, is superior to cement for attaching flanged pipes, blank flanges, lids, and manhole covers. It makes a better and more durable joint.

A combination of asbestos and india-rubber woven sheeting makes a superior flange joint, especially for steam purposes, as they resist both heat and moisture. To prevent adhesion to the iron (in the case of blank flange and manhole joints that require to be frequently broken), the flange should be rubbed over with powdered black lead before placing the cover.

Metallic rings are commonly used for flange joints. These are best *made with ½-inch* or ⅜-inch lead pipe, with the ends soldered evenly *together; the ring* is then covered with flax, and well smeared with red lead or paint. The pipe must not be beaten flat, but left round, so that when the joint is screwed up it may bed into any irregularities in the surfaces. The remaining space between the flanges is filled with rust or other cement.

Flange pipes can be jointed without the interposition of any packing material, by having the flanges faced in a lathe. In such case the surfaces are merely coated with white lead paint, and the joint tightened up.

Bolts used for jointing flanges, &c., should have a gummet of flax or tow, smeared with red or white lead, placed round their neck to bed under the head when screwed up.

Red and white lead should always be mixed with boiled linseed oil. Other oil can be made to answer, but not nearly so well.

The Laying of Main Pipes.

Special care is needed in the laying of main pipes. As a general rule the covering of soil over them should be at least 21 inches deep, to protect them from the influences of heavy traffic and low and varying temperatures.

The excavation to receive the pipes should not be unnecessarily wide, as the less filling up that is required the better, not to mention the saving in cost.

The bottom of the trench on which the pipes rest should be even and firm, and if not so, then thoroughly consolidated by punning. The soil should be scooped out at the various points in the trench bottom, where the sockets come, so that the body of the pipe may lie solid throughout its length. In cases where this cannot well be done resort may be had to underpinning.

Each pipe should be laid with the proper inclination or fall, and securely jointed; all joints being proved either with gas or air under high pressure whilst the trench is open.

In refilling the trench, the soil should be shovelled in in layers, and rammed firmly and equally all round and above the pipes.

Gas pipes should be free from excrescences, and moderately smooth on their inner surface.

They are better not coated internally with any kind of mixture soluble in naphtha or other hydrocarbon liquid. Such coating is soon dissolved by the gas, and drains partially away into the drip wells, the residue collecting into small viscid masses at different points, principally near to the joints. The coating can only be intended to reduce friction by rendering the surface smooth for the passage of the gas, because as a preservative to the iron, internally, it is not required. Its effect is to impede the flow. The slight deposit which takes place from the gas alone soon gives the metal a smooth coating. These objections do not, of course, apply to the internal coating of water pipes.

It is only for appearance sake, as a rule, that a covering of this description can be recommended for the outside of pipes. It often serves only to hide defects in the casting.

The reddish-brown oxide covering which cast-iron pipes acquire in a short time, when laid in ordinary soil, is one of the best preservatives of the metal. This covering is impervious to moisture, its effect being to arrest further corrosive action.

There are, however, circumstances where it is desirable and necessary to coat pipes externally, as, for example, when they are to be laid in soils intermixed with engine ashes, furnace slag, vitrified cinders, *clinker, dross, scoriæ,* or chemical refuse of any kind.

Furthermore, the pipes in such cases should be carefully embedded in good common soil obtained for that purpose, or puddled round with clay—especially protecting the upper side with a thick covering.

It is worse than useless to place clay *only underneath* the pipe; when so placed, it serves to receive and retain the water, which, percolating through the material forming the ground, is charged with acid bisulphides and other deleterious compounds. The metal of the pipe thus lying, as it were, in a bath of acidulous liquid, is destroyed sooner than it would be if no clay were present. The protection afforded by the clay should therefore be complete, all round the pipe, and particularly over its upper surface.

Gas pipes laid through arable land do it no harm, but rather good, inasmuch as they help to drain the land. The joints should be perfect however, as the escape of gas is fatal to vegetable life.

Mains in level ground should be laid with a slight inclination, say 1 foot in 400 yards, and at each lowest point a syphon or drip-well (Fig. 72) of cast-iron, should be placed underneath, and connected by a tube to the pipe to receive the liquid arising from condensation. Another form of syphon, with sockets to receive the main pipes, is shown in Fig. 73. In all cases where a main dips, a syphon is required at the place where the dip is reversed.

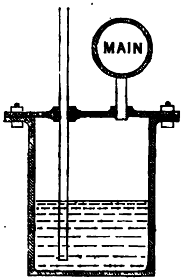


Fig. 72.

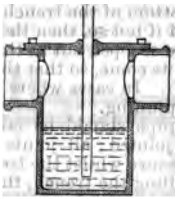


Fig. 73.

The liquor from these receptacles is pumped out perodically into a cask on wheels, and deposited in the tar-well on the gasworks.

In laying down mains in lieu of others of a smaller size, the difference in value between the two sizes of pipes only should be charged to capital account.

Appliances used in Mainlaying.

In beginning to lay an extensive length of main-pipes considerable delay, and consequent loss, is often experienced at first, owing to a want of foresight in providing beforehand the necessary men, tools, and other appliances required. The following is an enumeration of what it is necessary should be provided, varying according to the peculiarities of the district and the extent of the work to be done:—

One or two skilled main-layers.
A number of labourers, according to the extent of the work.
A paviour and his labourer. A night watchman..
A pick and spade (and a tool, if clay) for each labourer.

A supply of picks, pick-handles, and wedges should be kept in stock, to replace broken ones.
A screen for separating stones and soil.
Shear-legs or tripod; or, what is better, if the mains are of large diameter, a movable pipe-layer, supported on wheels, running on rails laid alongside of the trench.
Blocks, tackle, and ropes or chain.
A chain or clip to encircle the pipes.
Eight hand-spikes of wood, for moving the pipes about.
Two pieces of 2 or 3-inch wrought-iron tube (according to the size of main), on which to roll the pipe previous to lowering it to its place in the trench.
Two or four long iron bars, and two short ones.
Two planks for long and strong leverage.
Red lead, mixed up with boiled oil, if turned and bored joints.
Some cotton waste and old cards to clean the joints, if turned and bored.
A supply of spun yarn and lead, if open joints.
A wooden mallet for driving small bored and turned pipes.
Two or four oak blocks, strengthened with bolts or hoops, to lay against the pipe-sockets when driving.
A 3 or 4-inch cast-iron pipe, to swing with a rope or chain from centre of shear-legs when driving, or a wooden swing block if preferred.
Wood plugs for the various sizes of pipes and branches.
India-rubber cloth bags for plugging the mains. (See Fig. 74.)

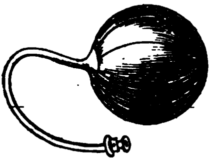


FIG. 74.

A lead pot and two ladles.
Chisels and caulking tools.
Some tarred rope, for trying the joints and pipes.
A coke fire-grate, for melting the lead and for use by the night watchman.
Three setts, with handles, for cutting any pipes required.
Two large hammers and three smaller ones.
Screwing tackle.
Some fine flax for indifferent joints.
A few casks of cement.
A bogie, or hand-drag, and two or three hand-barrows.
Portable bench, with vice attached.
Covered hand-cart, under lock and key.
A supply of good soil for bedding the pipes, and to prevent the contact of ashes, if such should be present in the cutting.
A spirit-level, and a straight-edge 10 or 12 feet long.
A supply of planking to cover up any part of the trench temporarily.
A box for the night watchman.
Two red signal lamps to warn passengers of the open trench during the dark hours.
Two stand-pipes, for the signal-lights.
Apparatus for proving the mains for leakage before filling up the trench.
Look up beforehand what bends, tees, thimbles, flanges, drip-wells, and other special castings will be required in the course of the work, and have them in readiness when needed.

In enlarging or replacing pipes, many services require to be coupled up and renewed, and in that case service-layers and tools should be got ready.

TABLES

Showing the Average Cost per Yard of Laying Mains, 9 feet long each, with Turned and Bored Joints, and with Lead Joints, including the Total Expense of Material (the pipes excepted), Excavating, Reinstating, and Maintaining the Ground for Six Months after Completion. Average Depth from the Surface of the Ground to the Upper Side of the Pipes, 1 foot 9 inches.

Diameter in Inches.	2.		2½.		3.		4.		5.		6.	
Description of Joint.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
In ordinary ballast	0 8	1 0	0 9	1 1	0 10	1 2	1 3	1 7	1 6	2 0	1 7	2 2
In roads macadamized with Welsh or limestone . . .	0 11	1 3	1 0	1 5	1 2	1 6	1 7	1 11	1 9	2 4	1 11	2 6
In ordinary paved streets . .	1 0	1 4	1 1	1 6	1 4	1 8	1 8	2 0	2 1	2 7	2 3	2 10
In bitumenized streets . . .	3 2	3 6	3 3	3 9	3 6	4 2	5 0	5 6	5 3	6 0	5 7	6 2
In footpaths made with sand or ashes	0 6	0 11	0 7	1 0	0 8	1 0	0 11	1 3	1 4	1 10	1 5	2 0
In footpaths flagged	0 8	1 0	0 9	1 1	0 10	1 2	1 3	1 7	1 6	2 0	1 7	2 2
In footpaths asphalted . . .	1 10	2 2	2 0	2 4	2 2	2 8	2 7	3 0	2 10	3 4	2 11	3 6

Diameter in Inches.	7.		8.		9.		10.		11.		12.	
Description of Joint.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
In ordinary ballast	1 10	2 6	2 1	2 10	2 2	3 0	2 6	3 6	2 8	3 10	2 11	4 2
In roads macadamized with Welsh or limestone . . .	2 2	2 10	2 5	3 2	2 6	3 4	2 10	3 10	3 1	4 3	3 4	4 7
In ordinary paved streets . .	2 5	3 1	2 8	3 5	2 9	3 7	3 1	4 1	3 4	4 6	3 7	4 10
In bitumenized streets . . .	5 10	6 9	6 1	7 2	6 2	7 6	6 6	8 0	6 8	8 4	7 11	9 8
In footpaths made with sand or ashes	1 7	2 3	1 11	2 8	2 0	2 10	2 4	3 4	2 6	3 8	2 9	4 0
In footpaths flagged	1 10	2 6	2 1	2 10	2 2	3 0	2 6	3 6	2 8	3 10	2 11	4 2
In footpaths asphalted . . .	3 2	3 10	3 5	4 3	3 6	4 4	3 10	4 10	4 0	5 2	4 4	5 7

Diameter in Inches.	13.		14.		15.		16.		17.		18.	
Description of Joint.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
In ordinary ballast.	3 3	4 9	3 5	5 2	3 9	5 7	4 4	6 5	4 8	7 0	5 0	7 5
In roads macadamized with Welsh or limestone . . .	3 8	5 2	3 10	5 7	4 2	6 0	4 9	6 10	5 2	7 6	5 6	7 11
In ordinary paved streets . .	3 11	5 5	4 1	5 10	4 5	6 8	5 0	7 1	5 4	7 8	5 8	8 1
In bitumenized streets . . .	8 3	10 8	8 5	10 8	9 0	11 4	9 8	12 3	10 0	12 10	10 6	13 6
In footpaths made with sand or ashes	3 0	4 7	3 8	5 0	3 7	5 5	4 2	6 3	4 6	6 10	4 10	7 3
In footpaths flagged	3 3	4 9	3 5	5 2	3 9	5 7	4 4	6 5	4 8	7 0	5 0	7 5
In footpaths asphalted . . .	4 9	6 3	5 0	6 9	5 3	7 1	5 10	7 11	6 2	8 6	6 6	9 0

Diameter in Inches.	19.		20.		21.		22.		23.		24.	
Description of Joint.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.	Turned and Bored.	Lead.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
In ordinary ballast.	5 8	8 2	6 3	8 10	6 8	9 4	7 1	9 9	7 4	10 0	7 7	11 2
In roads macadamized with Welsh or limestone . . .	6 2	8 8	6 9	9 4	7 2	9 10	7 7	10 3	7 10	10 6	8 1	11 8
In ordinary paved streets . .	6 4	8 10	7 0	9 7	7 5	10 1	7 10	10 6	8 1	10 9	8 4	12 0
In bitumenized streets . . .	11 10	15 2	12 6	16 0	13 0	16 6	13 6	17 0	13 8	17 8	14 0	18 6
In footpaths made with sand or ashes	5 6	8 0	6 0	8 7	6 6	9 2	6 10	9 6	7 2	9 10	7 4	11 0
In footpaths flagged	5 8	8 2	6 3	8 10	6 8	9 4	7 1	9 9	7 4	10 0	7 7	11 2
In footpaths asphalted . . .	7 2	9 9	7 9	10 4	8 2	10 10	8 7	11 3	8 10	11 6	9 1	13 8

TABLE

Giving Weight and Cost per Yard of ***Cast-Iron Main Gas Pipes 2, 3, and 4 inches*** *diameter, at Rates from £4 to £12 per Ton. (Calculated to the nearest* ***Penny.)***

Diameter in Inches.	2.			3.			4.		
Class of Joint.	Open.	T.&B.	Flinge	Open.	T.&B.	Flinge	Open.	T.&B.	Flinge
Weight pr. yd. in lbs.	25	26	25	41	42	41	53	54	54
Cost per yard at	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
£4 0 0 per ton.	0 11	0 11	0 11	1 6	1 6	1 6	1 11	1 11	1 11
4 2 6 ,,	0 11	0 11	0 11	1 6	1 7	1 6	1 11	2 0	2 0
4 5 0 ,,	0 11	1 0	0 11	1 7	1 7	1 7	2 0	2 1	2 1
4 7 6 ,,	1 0	1 0	1 0	1 7	1 8	1 7	2 1	2 1	2 1
4 10 0 ,,	1 0	1 1	1 0	1 8	1 8	1 8	2 2	2 2	2 2
4 12 6 ,,	1 0	1 1	1 0	1 8	1 9	1 8	2 2	2 3	2 3
4 15 0 ,,	1 1	1 1	1 1	1 9	1 9	1 9	2 3	2 3	2 3
4 17 6 ,,	1 1	1 2	1 1	1 9	1 10	1 9	2 4	2 4	2 4
5 0 0 ,,	1 1	1 2	1 1	1 10	1 11	1 10	2 4	2 5	2 5
5 2 6 ,,	1 2	1 2	1 2	1 11	1 11	1 11	2 5	2 6	2 6
5 5 0 ,,	1 2	1 3	1 2	1 11	2 0	1 11	2 6	2 6	2 6
5 7 6 ,,	1 2	1 3	1 2	2 0	2 0	2 0	2 7	2 7	2 7
5 10 0 ,,	1 3	1 3	1 3	2 0	2 1	2 0	2 7	2 8	2 8
5 12 6 ,,	1 3	1 4	1 3	2 1	2 1	2 1	2 8	2 9	2 9
5 15 0 ,,	1 3	1 4	1 3	2 1	2 2	2 1	2 9	2 9	2 9
5 17 6 ,,	1 4	1 4	1 4	2 2	2 2	2 2	2 9	2 10	2 10
6 0 0 ,,	1 4	1 5	1 4	2 2	2 3	2 2	2 10	2 11	2 11
6 2 6 ,,	1 4	1 5	1 4	2 3	2 4	2 3	2 11	2 11	2 11
6 5 0 ,,	1 5	1 5	1 5	2 3	2 4	2 3	2 11	3 0	3 0
6 7 6 ,,	1 5	1 6	1 5	2 4	2 5	2 4	3 0	3 1	3 1
6 10 0 ,,	1 5	1 6	1 5	2 5	2 5	2 5	3 1	3 2	3 2
6 12 6 ,,	1 6	1 6	1 6	2 5	2 6	2 5	3 2	3 2	3 2
6 15 0 ,,	1 6	1 7	1 6	2 6	2 6	2 6	3 2	3 3	3 3
6 17 6 ,,	1 6	1 7	1 6	2 6	2 7	2 6	3 3	3 4	3 4
7 0 0 ,,	1 7	1 8	1 7	2 7	2 8	2 7	3 4	3 5	3 5
7 2 6 ,,	1 7	1 8	1 7	2 7	2 8	2 7	3 4	3 5	3 5
7 5 0 ,,	1 7	1 8	1 7	2 8	2 9	2 8	3 5	3 6	3 6
7 7 6 ,,	1 8	1 9	1 8	2 8	2 9	2 8	3 6	3 7	3 7
7 10 0 ,,	1 8	1 9	1 8	2 9	2 10	2 9	3 7	3 7	3 7
7 12 6 ,,	1 8	1 9	1 8	2 9	2 10	2 9	3 7	3 8	3 7
7 15 0 ,,	1 9	1 10	1 9	2 10	2 11	2 10	3 8	3 9	3 9
7 17 6 ,,	1 9	1 10	1 9	2 11	2 11	2 11	3 9	3 10	3 10
8 0 0 ,,	1 9	1 10	1 9	2 11	3 0	2 11	3 9	3 10	3 10
8 2 6 ,,	1 10	1 11	1 10	3 0	3 1	3 0	3 10	3 11	3 11
8 5 0 ,,	1 10	1 11	1 10	3 0	3 1	3 0	3 11	4 0	4 0
8 7 6 ,,	1 10	1 11	1 10	3 1	3 2	3 1	4 0	4 0	4 0
8 10 0 ,,	1 11	2 0	1 11	3 1	3 2	3 1	4 0	4 1	4 1
8 12 6 ,,	1 11	2 0	1 11	3 2	3 3	3 2	4 1	4 2	4 2
8 15 0 ,,	1 11	2 0	1 11	3 2	3 3	3 2	4 2	4 3	4 3
8 17 6 ,,	2 0	2 1	2 0	3 3	3 4	3 3	4 2	4 3	4 3
9 0 0 ,,	2 0	2 1	2 0	3 4	3 5	3 4	4 3	4 4	4 5
9 2 6 ,,	2 0	2 1	2 0	3 4	3 5	3 4	4 4	4 5	4 4
9 5 0 ,,	2 1	2 2	2 1	3 5	3 6	3 5	4 5	4 6	4 6
9 7 6 ,,	2 1	2 2	2 1	3 5	3 6	3 5	4 5	4 6	4 6
9 10 0 ,,	2 1	2 2	2 1	3 6	3 7	3 6	4 6	4 7	4 7
9 12 6 ,,	2 2	2 3	2 2	3 6	3 7	3 6	4 7	4 8	4 8
9 15 0 ,,	2 2	2 3	2 2	3 7	3 8	3 7	4 7	4 8	4 8
9 17 6 ,,	2 2	2 4	2 2	3 7	3 8	3 7	4 8	4 9	4 9
10 0 6 ,,	2 2	2 4	2 2	3 8	3 9	3 8	4 9	4 10	4 10
10 5 0 ,,	2 3	2 4	2 3	3 9	3 10	3 9	4 10	4 11	4 11
10 10 0 ,,	2 3	2 5	2 3	3 10	3 11	3 10	5 0	5 1	5 1
10 15 0 ,,	2 3	2 6	2 3	3 11	4 0	3 11	5 1	5 2	5 2
11 0 0 ,,	2 3	2 6	2 3	4 0	4 2	4 0	5 2	5 4	5 4
11 5 0 ,,	2 6	2 7	2 6	4 1	4 3	4 1	5 4	5 5	5 5
11 10 0 ,,	2 7	2 8	2 7	4 3	4 4	4 3	5 5	5 7	5 7
12 0 0 ,,	2 8	2 9	2 8	4 5	4 6	4 5	5 8	5 9	5 9

TABLE

Giving Weight and Cost per Yard of Cast-Iron Main Gas Pipes 5, 6, and 7 inches diameter, at Rates from £4 to £12 per Ton. ***(Calculated to the nearest Penny.)***

Diameter in Inches.	5.			6.			7.		
Class of Joint.	Open.	T.&B.	Flnge	Open.	T.&B.	Flnge	Open.	T. & B.	Flnge
Weight pr. yd. in lbs.	77	79	78	91	93	92	121	124	123
Cost per yard at	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
£4 0 0 per ton.	2 9	2 10	2 9	3 3	3 4	3 3	4 4	4 5	4 5
4 2 6 „	2 10	2 11	2 10	3 4	3 5	3 5	4 5	4 7	4 6
4 5 0 „	2 11	3 0	3 0	3 5	3 6	3 6	4 7	4 8	4 8
4 7 6 „	3 0	3 1	3 1	3 6	3 7	3 7	4 9	4 10	4 10
4 10 0 „	3 1	3 2	3 2	3 8	3 9	3 8	4 10	5 0	4 11
4 12 6 „	3 2	3 3	3 3	3 9	3 10	3 10	5 0	5 1	5 1
4 15 0 „	3 3	3 4	3 4	3 10	3 11	3 11	5 2	5 3	5 3
4 17 6 „	3 4	3 5	3 5	4 0	4 1	4 0	5 4	5 5	5 4
5 0 0 „	3 5	3 6	3 6	4 1	4 2	4 1	5 5	5 6	5 6
5 2 6 „	3 6	3 7	3 7	4 2	4 3	4 3	5 6	5 8	5 8
5 5 0 „	3 7	3 8	3 8	4 3	4 4	4 4	5 8	5 10	5 9
5 7 6 „	3 8	3 9	3 9	4 4	4 5	4 5	5 10	5 11	5 11
5 10 0 „	3 9	3 10	3 10	4 6	4 7	4 6	5 11	6 1	6 0
5 12 6 „	3 10	4 0	3 11	4 7	4 8	4 7	6 1	6 3	6 2
5 15 0 „	3 11	4 1	4 0	4 8	4 9	4 9	6 2	6 4	6 4
5 17 6 „	4 0	4 2	4 1	4 9	4 11	4 10	6 4	6 6	6 5
6 0 0 „	4 1	4 3	4 2	4 10	5 0	4 11	6 6	6 8	6 7
6 2 6 „	4 2	4 4	4 3	5 0	5 1	5 0	6 7	6 9	6 9
6 5 0 „	4 3	4 5	4 4	5 1	5 2	5 2	6 9	6 11	6 10
6 7 6 „	4 4	4 6	4 5	5 2	5 3	5 3	6 11	7 1	7 0
6 10 0 „	4 6	4 7	4 6	5 3	5 5	5 4	7 0	7 2	7 2
6 12 6 „	4 7	4 8	4 7	5 4	5 6	5 5	7 2	7 4	7 3
6 15 0 „	4 8	4 9	4 8	5 6	5 7	5 7	7 4	7 6	7 5
6 17 6 „	4 9	4 10	4 9	5 7	5 9	5 8	7 5	7 7	7 7
7 0 0 „	4 10	4 11	4 10	5 8	5 10	5 9	7 7	7 9	7 8
7 2 6 „	4 11	5 0	5 0	5 9	5 11	5 10	7 8	7 11	7 10
7 5 0 „	5 0	5 1	5 1	5 11	6 0	5 11	7 10	8 0	8 0
7 7 6 „	5 1	5 2	5 2	6 0	6 1	6 1	8 0	8 2	8 1
7 10 0 „	5 2	5 3	5 3	6 1	6 3	6 2	8 1	8 4	8 3
7 12 6 „	5 3	5 5	5 4	6 2	6 4	6 3	8 3	8 5	8 4
7 15 0 „	5 4	5 6	5 5	6 3	6 5	6 4	8 4	8 7	8 6
7 17 6 „	5 5	5 7	5 6	6 5	6 6	6 6	8 6	8 9	8 8
8 0 0 „	5 6	5 8	5 7	6 6	6 8	6 7	8 8	8 10	8 9
8 2 6 „	5 7	5 9	5 8	6 7	6 9	6 8	8 9	9 0	8 11
8 5 0 „	5 8	5 10	5 9	6 8	6 10	6 9	8 11	9 2	9 1
8 7 6 „	5 9	5 11	5 10	6 10	6 11	6 10	9 1	9 3	9 2
8 10 0 „	5 10	6 0	5 11	6 11	7 0	7 0	9 2	9 5	9 4
8 12 6 „	5 11	6 1	6 0	7 0	7 2	7 1	9 4	9 7	9 6
8 15 0 „	6 0	6 2	6 1	7 1	7 3	7 2	9 5	9 8	9 7
8 17 6 „	6 1	6 3	6 2	7 3	7 4	7 3	9 7	9 10	9 9
9 0 0 „	6 2	6 4	6 3	7 4	7 6	7 5	9 9	10 0	9 10
9 2 6 „	6 3	6 5	6 4	7 5	7 7	7 6	9 10	10 1	10 0
9 5 0 „	6 4	6 6	6 5	7 6	7 8	7 7	10 0	10 3	10 2
9 7 6 „	6 5	6 7	6 6	7 7	7 9	7 8	10 2	10 5	10 4
9 10 0 „	6 6	6 8	6 7	7 9	7 10	7 10	10 3	10 6	10 5
9 12 6 „	6 7	6 9	6 8	7 10	8 0	7 11	10 5	10 8	10 7
9 15 0 „	6 8	6 10	6 9	7 11	8 1	8 0	10 6	10 10	10 8
9 17 6 „	6 9	6 11	6 11	8 0	8 2	8 1	10 8	10 11	10 10
10 0 0 „	6 11	7 1	7 0	8 2	8 4	8 3	10 10	11 1	11 0
10 5 0 „	7 1	7 3	7 2	8 4	8 6	8 5	11 1	11 4	11 3
10 10 0 „	7 3	7 5	7 4	8 6	8 9	8 7	11 4	11 8	11 6
10 15 0 „	7 5	7 7	7 6	8 9	8 11	8 10	11 7	11 11	11 10
11 0 0 „	7 7	7 9	7 8	8 11	9 2	9 0	11 11	12 2	12 1
11 5 0 „	7 9	7 11	7 10	9 2	9 4	0 2	12 2	12 5	12 4
11 10 0 „	7 11	8 1	8 0	9 4	9 6	9 5	12 5	12 9	12 8
12 0 0 „	8 3	8 6	8 4	9 9	10 0	9 10	13 0	13 3	13 2

TABLE

Giving Weight and Cost per Yard of Cast-Iron Main Gas Pipes 8, 9, and 10 inches diameter, at Rates from £4 to £12 per Ton. (*Calculated to the nearest Penny.*)

Diameter in Inches.	8.			9.			10.		
Class of Joint.	Open.	T.&B.	Flnge	Open.	T.&B.	Flnge	Open.	T. & B.	Flnge
Weight pr. yd. in lbs.	137	140	139	153	157	155	192	196	194
Cost per yard at	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
£4 0 0 per ton.	4 11	5 0	5 0	5 6	5 7	5 6	6 10	7 0	6 11
4 2 6 ,,	5 1	5 2	5 1	5 8	5 9	5 9	7 1	7 3	7 2
4 5 0 ,,	5 2	5 4	5 3	5 10	6 0	5 11	7 3	7 5	7 4
4 7 6 ,,	5 4	5 6	5 5	6 0	6 2	6 1	7 6	7 8	7 7
4 10 0 ,,	5 6	5 8	5 7	6 2	6 4	6 3	7 9	7 11	7 10
4 12 6 ,,	5 8	5 9	5 9	6 4	6 6	6 5	7 11	8 1	8 0
4 15 0 ,,	5 10	5 11	5 11	6 6	6 8	6 7	8 2	8 4	8 3
4 17 6 ,,	6 0	6 1	6 1	6 8	6 10	6 9	8 4	8 6	8 5
5 0 0 ,,	6 1	6 3	6 2	6 10	7 0	6 11	8 7	8 9	8 8
5 2 6 ,,	6 3	6 5	6 4	7 0	7 2	7 1	8 9	9 0	8 11
5 5 0 ,,	6 5	6 7	6 6	7 2	7 4	7 3	9 0	9 2	9 1
5 7 6 ,,	6 7	6 9	6 8	7 4	7 6	7 5	9 3	9 5	9 4
5 10 0 ,,	6 9	6 11	6 10	7 6	7 9	7 7	9 5	9 8	9 6
5 12 6 ,,	6 11	7 0	7 0	7 8	7 11	7 9	9 8	9 10	9 9
5 15 0 ,,	7 0	7 2	7 2	7 10	8 1	7 11	9 10	10 1	10 0
5 17 6 ,,	7 2	7 4	7 3	8 0	8 3	8 2	10 1	10 3	10 2
6 0 0 ,,	7 4	7 6	7 5	8 2	8 5	8 4	10 3	10 6	10 5
6 2 6 ,,	7 6	7 8	7 7	8 4	8 7	8 6	10 6	10 9	10 7
6 5 0 ,,	7 8	7 10	7 9	8 6	8 9	8 8	10 9	10 11	10 10
6 7 6 ,,	7 10	8 0	7 11	8 8	8 11	8 10	10 11	11 2	11 1
6 10 0 ,,	7 11	8 2	8 1	8 10	9 1	9 0	11 2	11 5	11 3
6 12 6 ,,	8 1	8 3	8 3	9 1	9 3	9 2	11 4	11 7	11 6
6 15 0 ,,	8 3	8 5	8 5	9 3	9 6	9 4	11 7	11 10	11 8
6 17 6 ,,	8 5	8 7	8 6	9 5	9 8	9 6	11 9	12 0	11 11
7 0 0 ,,	8 7	8 9	8 8	9 7	9 10	9 8	12 0	12 3	12 1
7 2 6 ,,	8 9	8 11	8 10	9 9	10 0	9 10	12 3	12 6	12 4
7 5 0 ,,	8 10	9 1	9 0	9 11	10 2	10 0	12 5	12 8	12 6
7 7 6 ,,	9 0	9 3	9 2	10 1	10 4	10 2	12 8	12 11	12 9
7 10 0 ,,	9 2	9 5	9 4	10 3	10 6	10 5	12 10	13 2	13 0
7 12 6 ,,	9 4	9 6	9 6	10 5	10 8	10 7	13 1	13 4	13 2
7 15 0 ,,	9 6	9 8	9 7	10 7	10 10	10 9	13 4	13 7	13 5
7 17 6 ,,	9 8	9 10	9 9	10 9	11 0	10 11	13 6	13 9	13 7
8 0 0 ,,	9 9	10 0	9 11	10 11	11 3	11 1	13 9	14 0	13 10
8 2 6 ,,	9 11	10 2	10 1	11 1	11 5	11 3	13 11	14 3	14 0
8 5 0 ,,	10 1	10 4	10 3	11 3	11 7	11 5	14 2	14 5	14 3
8 7 6 ,,	10 3	10 6	10 5	11 5	11 9	11 7	14 4	14 8	14 6
8 10 0 ,,	10 5	10 8	10 7	11 7	11 11	11 9	14 7	14 11	14 8
8 12 6 ,,	10 7	10 9	10 8	11 9	12 1	11 11	14 9	15 1	14 11
8 15 0 ,,	10 8	10 11	10 10	11 11	12 3	12 1	15 0	15 4	15 2
8 17 6 ,,	10 10	11 1	11 0	12 1	12 5	12 3	15 2	15 6	15 4
9 0 0 ,,	11 0	11 3	11 2	12 3	12 7	12 5	15 5	15 9	15 7
9 2 6 ,,	11 2	11 5	11 4	12 5	12 9	12 8	15 7	16 0	15 9
9 5 0 ,,	11 4	11 7	11 6	12 8	13 0	12 10	15 10	16 2	16 0
9 7 6 ,,	11 6	11 9	11 8	12 10	13 2	13 0	16 0	16 5	16 2
9 10 0 ,,	11 7	11 11	11 9	13 0	13 4	13 2	16 3	16 8	16 5
9 12 6 ,,	11 9	12 0	11 11	13 2	13 6	13 4	16 5	16 10	16 8
9 15 0 ,,	11 11	12 2	12 1	13 4	13 8	13 6	16 8	17 1	16 10
9 17 6 ,,	12 1	12 4	12 3	13 6	13 10	13 8	16 10	17 3	17 1
10 0 0 ,,	12 3	12 6	12 5	13 8	14 0	13 10	17 2	17 6	17 3
10 5 0 ,,	12 6	12 10	12 9	14 0	14 4	14 2	17 7	17 11	17 9
10 10 0 ,,	12 10	13 2	13 0	14 4	14 9	14 6	18 0	18 5	18 2
10 15 0 ,,	13 2	13 5	13 4	14 8	15 1	14 11	18 5	18 10	18 7
11 0 0 ,,	13 5	13 9	13 8	15 0	15 5	15 3	18 10	19 3	19 1
11 5 0 ,,	13 9	14 1	14 0	15 4	15 9	15 7	19 3	19 8	19 6
11 10 0 ,,	14 1	14 5	14 3	15 8	16 1	15 11	19 9	20 2	19 11
12 0 0 ,,	14 8	15 0	14 11	16 5	16 10	16 7	20 7	21 0	20 10

TABLE

Giving Weight and Cost per Yard of Cast-Iron Main Gas Pipes 11, 12, and 13 inches diameter, at Rates from £4 to £12 per Ton. (Calculated to the nearest Penny.)

Diameter in Inches.	11.						12.						13.					
Class of Joint.	Open.		T.&B.		Flnge		Open.		T.&B.		Flnge		Open.		T. & B.		Flnge	
Weight pr. yd. in lbs.	210		215		212		249		258		251		269		278		271	
Cost per yard at	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
£4 0 0 per ton.	7	6	7	8	7	7	8	11	9	0	9	0	9	7	9	9	9	8
4 2 6 ,,	7	9	7	11	7	10	9	2	9	4	9	3	9	11	10	1	10	0
4 5 0 ,,	8	0	8	2	8	0	9	5	9	7	9	6	10	3	10	4	10	3
4 7 6 ,,	8	2	8	5	8	3	9	9	9	11	9	10	10	6	10	8	10	7
4 10 0 ,,	8	5	8	8	8	6	10	0	10	2	10	1	10	10	11	0	10	11
4 12 6 ,,	8	8	8	11	8	9	10	3	10	5	10	4	11	1	11	3	11	2
4 15 0 ,,	8	11	9	1	9	0	10	6	10	9	10	8	11	5	11	7	11	6
4 17 6 ,,	9	2	9	4	9	3	10	10	11	0	10	11	11	9	11	11	11	10
5 0 0 ,,	9	4	9	7	9	5	11	1	11	4	11	3	12	0	12	2	12	1
5 2 6 ,,	9	7	9	10	9	8	11	4	11	7	11	6	12	4	12	6	12	5
5 5 0 ,,	9	10	10	1	9	11	11	7	11	10	11	9	12	7	12	10	12	8
5 7 6 ,,	10	1	10	4	10	2	11	11	12	2	12	0	12	11	13	1	13	0
5 10 0 ,,	10	4	10	7	10	5	12	2	12	5	12	4	13	3	13	5	13	4
5 12 6 ,,	10	7	10	10	10	8	12	5	12	8	12	7	13	6	13	9	13	7
5 15 0 ,,	10	10	11	1	10	10	12	9	13	0	12	11	13	10	14	0	13	11
5 17 6 ,,	11	0	11	3	11	1	13	1	13	3	13	2	14	1	14	4	14	3
6 0 0 ,,	11	3	11	6	11	4	13	4	13	7	13	5	14	5	14	8	14	6
6 2 6 ,,	11	6	11	9	11	7	13	7	13	10	13	9	14	9	14	11	14	10
6 5 0 ,,	11	9	12	0	11	10	13	11	14	1	14	0	15	0	15	3	15	2
6 7 6 ,,	11	11	12	3	12	1	14	2	14	5	14	3	15	4	15	6	15	5
6 10 0 ,,	12	3	12	6	12	4	14	5	14	8	14	7	15	7	15	10	15	9
6 12 6 ,,	12	5	12	8	12	6	14	9	15	0	14	10	15	11	16	2	16	0
6 15 0 ,,	12	8	13	0	12	9	15	0	15	3	15	2	16	3	16	5	16	4
6 17 6 ,,	12	11	13	2	13	0	15	3	15	6	15	5	16	6	16	9	16	8
7 0 0 ,,	13	2	13	5	13	3	15	7	15	10	15	8	16	10	17	1	16	11
7 2 6 ,,	13	5	13	8	13	6	15	10	16	1	16	0	17	1	17	4	17	3
7 5 0 ,,	13	7	13	10	13	9	16	1	16	5	16	3	17	5	17	8	17	7
7 7 6 ,,	13	10	14	2	14	0	16	5	16	8	16	6	17	9	18	0	17	10
7 10 0 ,,	14	2	14	5	14	2	16	8	16	11	16	10	18	0	18	3	18	2
7 12 6 ,,	14	4	14	8	14	5	16	11	17	3	17	1	18	4	18	7	18	5
7 15 0 ,,	14	6	14	11	14	8	17	3	17	6	17	4	18	7	18	11	18	9
7 17 6 ,,	14	9	15	1	14	11	17	6	17	9	17	8	18	11	19	2	19	1
8 0 0 ,,	15	0	15	4	15	2	17	10	18	1	17	11	19	3	19	6	19	4
8 2 6 ,,	15	3	15	7	15	4	18	1	18	4	18	2	19	6	19	10	19	8
8 5 0 ,,	15	6	15	10	15	7	18	4	18	7	18	5	19	10	20	1	20	0
8 7 6 ,,	15	8	16	1	15	10	18	8	18	11	18	9	20	1	20	5	20	3
8 10 0 ,,	15	11	16	4	16	1	18	11	19	2	19	0	20	5	20	9	20	7
8 12 6 ,,	16	2	16	7	16	4	19	2	19	6	19	4	20	9	21	0	20	10
8 15 0 ,,	16	5	16	10	16	7	19	6	19	9	19	7	21	0	21	4	21	2
8 17 6 ,,	16	8	17	0	16	9	19	9	20	1	19	11	21	4	21	8	21	6
9 0 0 ,,	16	10	17	3	17	0	20	0	20	4	20	2	21	7	21	11	21	9
9 2 6 ,,	17	1	17	6	17	3	20	4	20	7	20	5	21	11	22	3	22	1
9 5 0 ,,	17	4	17	9	17	6	20	7	20	11	20	9	22	3	22	7	22	5
9 7 6 ,,	17	7	18	0	17	9	20	10	21	2	21	0	22	6	22	10	22	8
9 10 0 ,,	17	10	18	3	18	0	21	2	21	6	21	4	22	10	23	2	23	0
9 12 6 ,,	18	1	18	6	18	3	21	5	21	9	21	7	23	1	23	6	23	4
9 15 0 ,,	18	3	18	9	18	6	21	8	22	0	21	10	23	5	23	9	23	7
9 17 6 ,,	18	6	19	0	18	8	22	0	22	4	22	2	23	9	24	1	23	11
10 0 0 ,,	18	9	19	2	18	11	22	3	22	7	22	5	24	0	24	5	24	2
10 5 0 ,,	19	3	19	8	19	5	22	9	23	2	23	0	24	7	25	0	24	10
10 10 0 ,,	19	8	20	2	19	10	23	4	23	9	23	6	25	3	25	7	25	5
10 15 0 ,,	20	2	20	8	20	4	23	10	24	3	24	1	25	10	26	2	26	0
11 0 0 ,,	20	8	21	1	20	10	24	5	24	10	24	8	26	5	26	10	26	7
11 5 0 ,,	21	1	21	7	21	3	25	0	25	5	25	3	27	0	27	5	27	3
11 10 0 ,,	21	7	22	1	21	9	25	7	26	0	25	9	27	7	28	0	27	10
12 0 0 ,,	22	6	23	0	22	8	26	8	27	1	26	11	28	10	29	8	29	0

TABLE

Giving Weight and Cost per yard of Cast-Iron Main Gas Pipes 14, 15, and 16 inches diameter, at Rates from £4 to £12 per Ton. (Calculated to the nearest Penny.)

Diameter in Inches.	14.			15.			16.		
Class of Joint.	Open.	T.&B.	Flnge	Open.	T.&B.	Flnge	Open.	T. & B.	Flnge
Weight pr. yd. in lbs.	289	293	291	309	314	311	363	368	366
Cost per yard at	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
£4 0 0 per ton.	10 4	10 6	10 5	11 0	11 3	11 1	13 0	13 2	13 1
4 2 6 ,,	10 8	10 9	10 9	11 5	11 7	11 5	13 4	13 7	13 6
4 5 0 ,,	11 0	11 1	11 1	11 9	11 11	11 10	13 9	14 0	13 11
4 7 6 ,,	11 3	11 5	11 4	12 1	12 3	12 2	14 2	14 5	14 4
4 10 0 ,,	11 7	11 9	11 8	12 5	12 7	12 6	14 7	14 9	14 8
4 12 6 ,,	11 11	12 1	12 0	12 9	13 0	12 10	15 0	15 2	15 1
4 15 0 ,,	12 3	12 5	12 4	13 1	13 4	13 2	15 5	15 7	15 6
4 17 6 ,,	12 7	12 9	12 8	13 5	13 8	13 6	15 10	16 0	15 11
5 0 0 ,,	12 11	13 1	13 0	13 10	14 0	13 11	16 2	16 5	16 4
5 2 6 ,,	13 3	13 5	13 4	14 2	14 4	14 3	16 7	16 10	16 9
5 5 0 ,,	13 7	13 9	13 8	14 6	14 9	14 7	17 0	17 3	17 2
5 7 6 ,,	13 10	14 1	14 0	14 10	15 1	14 11	17 5	17 8	17 7
5 10 0 ,,	14 2	14 5	14 3	15 2	15 5	15 3	17 10	18 1	18 0
5 12 6 ,,	14 6	14 9	14 7	15 6	15 9	15 7	18 3	18 6	18 5
5 15 0 ,,	14 10	15 0	14 11	15 10	16 1	15 11	18 8	18 11	18 9
5 17 6 ,,	15 2	15 4	15 3	16 3	16 6	16 4	19 0	19 4	19 2
6 0 0 ,,	15 6	15 8	15 7	16 7	16 10	16 8	19 5	19 8	19 7
6 2 6 ,,	15 10	16 0	15 11	16 11	17 2	17 0	19 10	20 2	20 0
6 5 0 ,,	16 1	16 4	16 3	17 3	17 6	17 4	20 3	20 6	20 5
6 7 6 ,,	16 5	16 8	16 7	17 7	17 10	17 8	20 8	20 11	20 10
6 10 0 ,,	16 9	17 0	16 11	17 11	18 3	18 0	21 1	21 4	21 3
6 12 6 ,,	17 1	17 4	17 3	18 3	18 7	18 5	21 6	21 9	21 8
6 15 0 ,,	17 5	17 8	17 6	18 7	18 11	18 9	21 10	22 2	22 1
6 17 6 ,,	17 9	18 0	17 10	19 0	19 3	19 1	22 3	22 7	22 6
7 0 0 ,,	18 1	18 4	18 2	19 4	19 7	19 5	22 8	23 0	22 10
7 2 6 ,,	18 5	18 8	18 6	19 8	20 0	19 9	23 1	23 5	23 3
7 5 0 ,,	18 8	18 11	18 10	20 0	20 4	20 1	23 6	23 10	23 8
7 7 6 ,,	19 0	19 4	19 2	20 4	20 8	20 6	23 11	24 3	24 1
7 10 0 ,,	19 4	19 7	19 6	20 8	21 0	20 10	24 4	24 8	24 6
7 12 6 ,,	19 8	19 11	19 10	21 0	21 5	21 2	24 9	25 1	24 11
7 15 0 ,,	20 0	20 3	20 2	21 4	21 9	21 6	25 1	25 5	25 4
7 17 6 ,,	20 4	20 7	20 6	21 9	22 1	21 10	25 6	25 11	25 9
8 0 0 ,,	20 8	20 11	20 9	22 1	22 5	22 2	25 11	26 3	26 2
8 2 6 ,,	21 0	21 3	21 1	22 5	22 9	22 7	26 4	26 8	26 7
8 5 0 ,,	21 3	21 7	21 5	22 9	23 2	22 11	26 9	27 1	26 11
8 7 6 ,,	21 7	21 11	21 9	23 1	23 6	23 3	27 2	27 6	27 4
8 10 0 ,,	21 11	22 3	22 1	23 5	23 10	23 7	27 6	27 11	27 9
8 12 6 ,,	22 3	22 7	22 5	23 10	24 2	23 11	27 11	28 4	28 2
8 15 0 ,,	22 7	22 11	22 9	24 2	24 6	24 3	28 4	28 9	28 7
8 17 6 ,,	22 11	23 3	23 1	24 6	24 10	24 8	28 9	29 2	29 0
9 0 0 ,,	23 3	23 6	23 4	24 10	25 3	25 0	29 2	29 7	29 5
9 2 6 ,,	23 7	23 10	23 9	25 2	25 7	25 4	29 7	30 0	29 10
9 5 0 ,,	23 10	24 2	24 0	25 6	25 11	25 8	30 0	30 5	30 3
9 7 6 ,,	24 2	24 6	24 4	25 10	26 3	26 0	30 5	30 10	30 8
9 10 0 ,,	24 6	24 10	24 8	26 2	26 7	26 4	30 9	31 2	31 0
9 12 6 ,,	24 10	25 2	25 0	26 7	27 0	26 9	31 2	31 8	31 5
9 15 0 ,,	25 2	25 6	25 4	26 11	27 4	27 1	31 7	32 0	31 10
9 17 6 ,,	25 6	25 10	25 8	27 3	27 8	27 5	32 0	32 5	32 3
10 0 0 ,,	25 10	26 2	26 0	27 7	28 0	27 9	32 5	32 10	32 8
10 5 0 ,,	26 5	26 10	26 7	28 3	28 9	28 5	33 3	33 8	33 6
10 10 0 ,,	27 1	27 5	27 3	28 11	29 5	29 2	34 0	34 6	34 4
10 15 0 ,,	27 9	28 1	27 11	29 8	30 2	29 10	34 10	35 4	35 1
11 0 0 ,,	28 4	28 9	28 7	30 4	30 10	30 6	35 8	36 2	35 11
11 5 0 ,,	29 0	29 5	29 3	31 0	31 6	31 3	36 5	36 11	36 9
11 10 0 ,,	29 8	30 1	29 10	31 9	32 3	31 11	37 3	37 9	37 7
12 0 0 ,,	30 11	31 5	31 2	33 1	33 8	33 4	38 11	39 5	39 2

TABLE

Giving Weight and Cost per yard of Cast-Iron ***Main Gas Pipes***, 17, 18, *and* 19 *inches diameter, at Rates from £4 to £12 per Ton.* (*Calculated to the nearest Penny.*)

Diameter in Inches.	17.			18.			19.		
Class of Joint.	Open.	T.&B.	Flnge	Open.	T.&B.	Flnge	Open.	T.&B.	Flnge
Weight pr. yd. in lbs	384	390	387	406	412	409	468	475	472
Cost per yard at	s. d.	s. d.	s. d.	s d.	s. d.	s. d.	s. d.	s. d.	s d.
£4 0 0 per ton	13 8	13 11	13 10	14 6	14 8	14 7	16 8	16 11	16 10
4 2 6 „	14 2	14 4	14 3	14 11	15 2	15 1	17 3	17 6	17 5
4 5 0 „	14 7	14 9	14 8	15 5	15 7	15 6	17 9	18 0	17 11
4 7 6 „	15 0	15 3	15 1	15 10	16 1	16 0	18 3	18 7	18 5
4 10 0 „	15 5	15 8	15 6	16 4	16 7	16 5	18 10	19 1	18 11
4 10 6 „	15 10	16 1	15 11	16 9	17 0	16 11	19 4	19 7	19 6
4 12 0 „	16 3	16 6	16 5	17 2	17 6	17 4	19 10	20 2	20 0
4 15 6 „	16 9	17 0	16 9	17 8	17 11	17 10	20 4	20 8	20 7
5 0 0 „	17 2	17 5	17 3	18 1	18 5	18 3	20 11	21 2	21 1
5 2 6 „	17 7	17 10	17 9	18 7	18 10	18 9	21 5	21 9	21 7
5 5 0 „	18 0	18 3	18 2	19 0	19 4	19 2	21 11	22 3	22 1
5 7 6 „	18 5	18 9	18 7	19 6	19 9	19 8	22 6	22 10	22 8
5 10 0 „	18 10	19 2	19 0	19 11	20 3	20 1	23 0	23 4	23 2
5 12 6 „	19 3	19 7	19 5	20 5	20 8	20 6	23 6	23 10	23 8
5 15 0 „	19 8	20 0	19 10	20 10	21 2	21 0	24 0	24 5	24 3
5 17 6 „	20 2	20 5	20 4	21 4	21 7	21 5	24 7	24 11	24 9
6 0 0 „	20 7	20 11	20 9	21 9	22 1	21 11	25 1	25 5	25 3
6 2 6 „	21 0	21 4	21 2	22 2	22 6	22 4	25 7	26 0	25 10
6 5 0 „	21 5	21 9	21 7	22 8	23 0	22 10	26 1	26 6	26 4
6 7 6 „	21 10	22 2	22 0	23 1	23 5	23 3	26 8	27 0	26 10
6 10 0 „	22 3	22 7	22 5	23 7	23 11	23 9	27 2	27 7	27 5
6 12 6 „	22 9	23 1	22 11	24 0	24 4	24 2	27 8	28 1	27 11
6 15 0 „	23 2	23 6	23 4	24 5	24 10	24 8	28 2	28 7	28 5
6 17 6 „	23 7	23 11	23 9	24 11	25 3	25 1	28 7	29 2	29 0
7 0 0 „	24 0	24 4	24 2	25 4	25 9	25 7	29 3	29 8	29 6
7 2 6 „	24 5	24 10	24 7	25 10	26 3	26 0	29 9	30 3	30 0
7 5 0 „	24 10	25 3	25 0	26 3	26 8	26 6	30 3	30 9	30 7
7 7 6 „	25 3	25 8	25 6	26 9	27 2	26 11	30 10	31 3	31 1
7 10 0 „	25 8	26 1	25 11	27 2	27 7	27 5	31 4	31 10	31 8
7 12 6 „	26 2	26 7	26 4	27 8	28 1	27 10	31 10	32 4	32 2
7 15 0 „	26 7	27 0	26 9	28 1	28 6	28 3	32 4	32 10	32 8
7 17 6 „	27 0	27 5	27 2	28 7	29 0	28 9	32 11	33 5	33 2
8 0 0 „	27 5	27 10	27 8	29 0	29 5	29 2	33 5	33 11	33 8
8 2 6 „	27 10	28 4	28 1	29 5	29 11	29 8	33 11	34 6	34 3
8 5 0 „	28 3	28 9	28 6	29 11	30 4	30 1	34 6	35 0	34 9
8 7 6 „	28 8	29 2	28 11	30 4	30 10	30 7	35 0	35 6	35 4
8 10 0 „	29 2	29 7	29 4	30 10	31 3	31 0	35 6	36 0	35 10
8 12 6 „	29 7	30 0	29 10	31 3	31 8	31 6	36 1	36 7	36 4
8 15 0 „	30 0	30 5	30 3	31 8	32 2	31 11	36 7	37 1	36 10
8 17 6 „	30 5	30 11	30 8	32 2	32 8	32 5	37 1	37 8	37 5
9 0 0 „	30 10	31 4	31 1	32 7	33 1	32 10	37 7	38 2	37 11
9 2 6 „	31 3	31 9	31 6	33 1	33 7	33 4	38 2	38 8	38 5
9 5 0 „	31 8	32 2	31 11	33 6	34 0	33 9	38 8	39 3	39 0
9 7 6 „	32 1	32 8	32 5	34 0	34 6	34 3	39 2	39 9	39 6
9 10 0 „	32 7	33 1	32 10	34 5	34 11	34 8	39 8	40 3	40 0
9 12 6 „	33 0	33 6	33 3	34 11	35 5	35 2	40 3	40 10	40 7
9 15 0 „	33 5	33 11	33 8	35 4	35 10	35 7	40 9	41 4	41 1
9 17 6 „	33 10	34 5	34 1	35 10	36 4	36 1	41 3	41 11	41 7
10 0 0 „	34 3	34 10	34 7	36 8	36 9	36 6	41 9	42 5	42 2
10 5 0 „	35 2	35 8	35 5	37 2	37 8	37 5	42 10	43 6	43 2
10 10 0 „	36 0	36 7	36 3	38 1	38 7	38 4	43 10	44 6	44 3
10 15 0 „	36 10	37 5	37 2	38 11	39 6	39 3	44 11	45 7	45 4
11 0 0 „	37 8	38 4	38 0	39 10	40 5	40 2	45 11	46 8	46 4
11 5 0 „	38 7	39 2	38 10	40 9	41 4	41 1	47 0	47 8	47 5
11 10 0 „	39 5	40 0	39 9	41 8	42 4	42 0	48 1	48 9	48 5
12 0 0 „	41 2	41 9	41 5	43 6	44 2	43 10	50 2	50 11	50 7

TABLE

Giving Weight and Cost per Yard of Cast-Iron Main Gas Pipes, 20, 21, and 22 diameter, at Rates from £4 to £12 per Ton. (Calculated to the nearest Penn

Diameter in Inches.	20.			21.			22.	
Class of Joint.	Open.	T.& B.	Flnge	Open.	T.& B.	Flnge	Open.	T.& B.
Weight pr. yd. in lbs.	492	500	496	516	524	520	586	595
Cost per yard at	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
£4 0 0 per ton.	17 7	17 10	17 8	18 5	18 8	18 7	20 11	21 3
4 2 6 "	18 1	18 5	18 3	19 0	19 4	19 2	21 7	21 11
4 5 0 "	18 8	19 0	18 10	19 7	19 11	19 9	22 3	22 7
4 7 6 "	19 3	19 6	19 5	20 2	20 6	20 4	22 11	23 3
4 10 0 "	19 9	20 0	19 11	20 9	21 1	20 11	23 6	23 11
4 12 6 "	20 4	20 8	20 6	21 4	21 8	21 6	24 2	24 7
4 15 0 "	20 10	21 2	21 0	21 10	22 3	22 1	24 10	25 3
4 17 6 "	21 5	21 9	21 7	22 6	22 10	22 8	25 6	25 11
5 0 0 "	21 11	22 4	22 2	23 0	23 5	23 2	26 2	26 7
5 2 6 "	22 6	22 11	22 8	23 7	24 0	23 9	26 10	27 3
5 5 0 "	23 1	23 5	23 3	24 2	24 7	24 4	27 5	27 11
5 7 6 "	23 7	24 0	23 10	24 9	25 2	25 0	28 1	28 7
5 10 0 "	24 2	24 7	24 4	25 4	25 9	25 6	28 9	29 3
5 12 6 "	24 9	25 1	24 11	25 11	26 4	26 1	29 5	29 11
5 15 0 "	25 3	25 8	25 5	26 6	26 11	26 8	30 1	30 6
5 17 6 "	25 10	26 3	26 0	27 1	27 6	27 3	30 9	31 3
6 0 0 "	26 4	26 9	26 7	27 8	28 1	27 10	31 5	31 10
6 2 6 "	26 11	27 4	27 2	28 3	28 8	28 5	32 0	32 6
6 5 0 "	27 5	27 11	27 8	28 9	29 3	29 0	32 8	33 2
6 7 6 "	28 0	28 6	28 3	29 4	29 10	29 7	33 4	33 10
6 10 0 "	28 7	29 0	28 9	29 11	30 5	30 2	34 0	34 6
6 12 6 "	29 1	29 7	29 4	30 6	31 0	30 9	34 8	35 2
6 15 0 "	29 8	30 1	29 11	31 1	31 7	31 4	35 4	35 10
6 17 6 "	30 2	30 8	30 5	31 8	32 2	31 11	36 0	36 6
7 0 0 "	30 9	31 3	31 0	32 3	32 9	32 6	36 7	37 2
7 2 6 "	31 4	31 10	31 7	32 10	33 4	33 1	37 3	37 10
7 5 0 "	31 10	32 4	32 1	33 5	33 11	33 8	37 11	38 6
7 7 6 "	32 5	32 11	32 8	34 0	34 6	34 3	38 7	39 2
7 10 0 "	32 11	33 6	33 2	34 7	35 1	34 10	39 3	39 10
7 12 6 "	33 6	34 0	33 9	35 2	35 8	35 5	39 11	40 6
7 15 0 "	34 0	34 7	34 4	35 8	36 3	36 0	40 6	41 2
7 17 6 "	34 7	35 2	34 11	36 3	36 10	36 7	41 2	41 10
8 0 0 "	35 2	35 8	35 5	36 10	37 5	37 2	41 10	42 6
8 2 6 "	35 8	36 3	36 0	37 5	38 0	37 9	42 6	43 2
8 5 0 "	36 3	36 10	36 6	38 0	38 7	38 4	43 2	43 10
8 7 6 "	36 9	37 5	37 1	38 7	39 2	38 11	43 10	44 6
8 10 0 "	37 4	37 11	37 8	39 2	39 9	39 5	44 6	45 2
8 12 6 "	37 11	38 6	38 2	39 9	40 4	40 0	45 2	45 10
8 15 0 "	38 5	39 1	38 9	40 4	40 11	40 7	45 9	46 6
8 17 6 "	39 0	39 7	39 4	40 11	41 6	41 2	46 5	47 2
9 0 0 "	39 6	40 2	39 10	41 5	42 1	41 9	47 1	47 10
9 2 6 "	40 1	40 9	40 5	42 0	42 8	42 4	47 9	48 6
9 5 0 "	40 7	41 3	40 11	42 7	43 3	42 11	48 5	49 2
9 7 6 "	41 2	41 10	41 6	43 2	43 10	43 6	49 1	49 10
9 10 0 "	41 9	42 5	42 1	43 9	44 5	44 1	49 8	50 5
9 12 6 "	42 3	43 0	42 8	44 4	45 0	44 8	50 4	51 1
9 15 0 "	42 10	43 6	43 2	44 11	45 7	45 3	51 0	51 9
9 17 6 "	43 5	44 1	43 9	45 6	46 2	45 10	51 8	52 5
10 0 0 "	43 11	44 8	44 3	46 1	46 9	46 5	52 4	53 1
10 5 0 "	45 0	45 9	45 5	47 3	47 11	47 7	53 7	54 5
10 10 0 "	46 1	46 10	46 6	48 4	49 1	48 9	54 11	55 9
10 15 0 "	47 3	48 0	47 7	49 6	50 3	49 11	56 3	57 1
11 0 0 "	48 4	49 1	48 8	50 8	51 5	51 1	57 7	58 5
11 5 0 "	49 5	50 3	49 10	51 10	52 7	52 3	58 10	59 9
11 10 0 "	50 6	51 4	50 11	53 0	53 10	53 5	60 2	61 1
12 0 0 "	52 8	53 7	53 2	55 3	56 2	55 8	62 9	63 9

TABLE

***Giving Weight** and Cost per Yard of **Cast-Iron** Main Gas Pipes, **23, 24, and 30 inches diameter, at** Rates from £4 to £12 **per Ton.** (Calculated to the nearest **Penny.**)*

Diameter in Inches.	23.			24.			30.		
Class of Joint.	Open.	T.&B.	Flnge	Open.	T.&B.	Flnge	Open.	T. & B.	Flnge
Weight pr. yd. in lbs.	611	621	616	688	699	693	980	995	987
Cost per yard at	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
£4 0 0 per ton.	21 10	22 2	22 0	24 7	24 11	24 9	35 0	35 6	35 3
4 2 6 ,,	22 6	22 10	22 8	25 4	25 9	25 6	36 1	36 8	36 4
4 5 0 ,,	23 2	23 7	23 4	26 1	26 6	26 3	37 2	37 9	37 5
4 7 6 ,,	23 10	24 3	24 1	26 11	27 4	27 1	38 3	38 10	38 7
4 10 0 ,,	24 6	24 11	24 9	27 8	28 1	27 10	39 4	40 0	39 8
4 12 6 ,,	25 3	25 8	25 5	28 5	28 10	28 7	40 6	41 1	40 9
4 15 0 ,,	25 11	26 4	26 1	29 2	29 8	29 5	41 7	42 2	41 10
4 17 6 ,,	26 7	27 0	26 10	29 11	30 5	30 2	42 8	43 4	43 0
5 0 0 ,,	27 3	27 9	27 6	30 8	31 2	30 11	43 9	44 5	44 1
5 2 6 ,,	28 0	28 5	28 2	31 6	32 0	31 9	44 10	45 6	45 2
5 5 0 ,,	28 8	29 1	28 10	32 3	32 9	32 6	45 11	46 8	46 3
5 7 6 ,,	29 4	29 10	29 7	33 0	33 7	33 3	47 0	47 9	47 4
5 10 0 ,,	30 0	30 6	30 3	33 9	34 4	34 0	48 1	48 10	48 5
5 12 6 ,,	30 8	31 2	30 11	34 7	35 1	34 10	49 3	50 0	49 7
5 15 0 ,,	31 4	31 10	31 7	35 4	35 11	35 7	50 4	51 1	50 8
5 17 6 ,,	32 1	32 7	32 4	36 1	36 8	36 4	51 5	52 2	51 9
6 0 0 ,,	32 9	33 3	33 0	36 10	37 5	37 1	52 6	53 4	52 10
6 2 6 ,,	33 5	34 0	33 8	37 8	38 3	37 11	53 7	54 5	54 0
6 5 0 ,,	34 1	34 8	34 4	38 5	39 0	38 8	54 8	55 6	55 1
6 7 6 ,,	34 9	35 4	35 1	39 2	39 9	39 5	55 9	56 8	56 2
6 10 0 ,,	35 5	36 0	35 9	39 11	40 7	40 2	56 10	57 9	57 3
6 12 6 ,,	36 2	36 9	36 5	40 8	41 4	41 0	58 0	58 10	58 5
6 15 0 ,,	36 10	37 5	37 1	41 5	42 1	41 9	59 1	59 11	59 6
6 17 6 ,,	37 6	38 1	37 10	42 3	42 11	42 6	60 2	61 0	60 7
7 0 0 ,,	38 2	38 10	38 6	43 0	43 8	43 4	61 3	62 2	61 8
7 2 6 ,,	38 10	39 6	39 2	43 9	44 6	44 1	62 4	63 3	62 9
7 5 0 ,,	39 6	40 2	39 10	44 6	45 3	44 10	63 5	64 5	63 11
7 7 6 ,,	40 3	40 11	40 7	45 4	46 0	45 7	64 6	65 6	65 0
7 10 0 ,,	40 11	41 7	41 3	46 1	46 10	46 5	65 7	66 7	66 1
7 12 6 ,,	41 7	42 3	41 11	46 10	47 7	47 2	66 9	67 8	67 2
7 15 0 ,,	42 3	42 11	42 7	47 7	48 4	47 11	67 10	68 10	68 3
7 17 6 ,,	42 11	43 8	43 4	48 5	49 2	48 9	68 11	69 11	69 5
8 0 0 ,,	43 8	44 4	44 0	49 2	49 11	49 6	70 0	71 0	70 6
8 2 6 ,,	44 4	45 1	44 8	49 11	50 9	50 3	71 1	72 1	71 7
8 5 0 ,,	45 0	45 9	45 4	50 8	51 6	51 0	72 2	73 3	72 8
8 7 6 ,,	45 8	46 5	46 1	51 5	52 3	51 10	73 3	74 4	73 10
8 10 0 ,,	46 4	47 1	46 9	52 2	53 0	52 7	74 4	75 6	74 11
8 12 6 ,,	47 0	47 10	47 5	53 0	53 10	53 4	75 6	76 8	76 0
8 15 0 ,,	47 9	48 6	48 2	53 9	54 7	54 2	76 7	77 9	77 1
8 17 6 ,,	48 5	49 3	48 10	54 6	55 5	54 11	77 8	78 10	78 3
9 0 0 ,,	49 1	49 11	49 6	55 3	56 2	55 8	78 9	79 11	79 4
9 2 6 ,,	49 9	50 7	50 2	56 1	56 11	56 6	79 10	81 1	80 5
9 5 0 ,,	50 5	51 3	50 10	56 10	57 9	57 3	80 11	82 2	81 6
9 7 6 ,,	51 2	52 0	51 7	57 7	58 6	58 0	82 0	83 3	82 7
9 10 0 ,,	51 10	52 8	52 3	58 4	59 3	58 9	83 1	84 5	83 8
9 12 6 ,,	52 6	53 4	52 11	59 2	60 1	59 7	84 2	85 6	84 10
9 15 0 ,,	53 2	54 1	53 7	59 11	60 10	60 4	85 4	86 7	85 11
9 17 6 ,,	53 10	54 9	54 4	60 8	61 8	61 1	86 5	87 9	87 0
10 0 0 ,,	54 7	55 5	55 0	61 5	62 5	61 10	87 6	88 10	88 1
10 5 0 ,,	55 11	56 10	56 4	62 11	64 0	63 5	89 8	91 0	90 4
10 10 0 ,,	57 3	58 2	57 9	64 6	65 6	64 11	91 10	93 3	92 6
10 15 0 ,,	58 8	59 7	59 2	66 0	67 1	66 6	94 1	95 6	94 9
11 0 0 ,,	60 0	61 0	60 6	67 7	68 8	68 1	96 3	97 9	96 11
11 5 0 ,,	61 4	62 4	61 10	69 1	70 2	69 7	98 5	99 11	99 2
11 10 0 ,,	62 9	63 9	63 3	70 8	71 9	71 2	100 7	102 2	101 4
12 0 0 ,,	65 5	66 6	66 0	73 8	74 11	74 3	105 0	106 7	105 9

TABLE

Giving Weight and Cost per yard of Cast-Iron Main Gas Pipes, 36, 42, *and* 48 *inches diameter, at Rates from* £4 *to* £12 *per Ton. (Calculated to the nearest Penny.)*

Diameter in Inches.	36.			42.			48.		
Class of Joint.	Open.	T.&B.	Flnge	Open.	T.&B.	Flnge	Open.	T. & B.	Flnge
Weight pr. yd. in lbs.	1320	1341	1330	1621	1646	1633	1946	1976	1961
Cost per yard at	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
£4 0 0 per ton.	47 2	47 11	47 6	57 11	58 9	58 4	69 6	70 7	70 0
4 2 6 ,,	48 7	49 5	49 0	59 8	60 7	60 2	71 8	72 9	72 3
4 5 0 ,,	50 1	50 11	50 5	61 6	62 5	61 11	73 10	75 0	74 5
4 7 6 ,,	51 7	52 5	51 11	63 4	64 4	63 9	75 11	77 2	76 7
4 10 0 ,,	53 0	53 10	53 5	65 1	66 2	65 7	78 2	79 5	78 9
4 12 6 ,,	54 6	55 4	54 11	66 11	68 0	67 5	80 4	81 7	81 0
4 15 0 ,,	56 0	56 10	56 5	68 9	69 10	69 3	82 6	83 10	83 2
4 17 6 ,,	57 5	58 4	57 11	70 7	71 8	71 1	84 8	86 0	85 4
5 0 0 ,,	58 11	59 10	59 4	72 4	73 6	72 11	86 10	88 2	87 6
5 2 6 ,,	60 4	61 4	60 10	74 2	75 4	74 9	89 1	90 5	89 9
5 5 0 ,,	61 10	62 10	62 4	76 0	77 2	76 6	91 3	92 7	91 11
5 7 6 ,,	63 4	64 4	63 10	77 10	79 0	78 4	93 5	94 10	94 1
5 10 0 ,,	64 10	65 10	65 4	79 7	80 10	80 2	95 7	97 0	96 3
5 12 6 ,,	66 4	67 4	66 10	81 5	82 8	82 0	97 9	99 3	98 6
5 15 0 ,,	67 9	68 10	68 3	83 3	84 6	83 10	99 11	101 5	100 8
5 17 6 ,,	69 3	70 4	69 9	85 0	86 4	85 8	102 1	103 8	102 10
6 0 0 ,,	70 8	71 10	71 3	86 10	88 2	87 6	104 3	105 10	105 1
6 2 6 ,,	72 2	73 4	72 9	88 8	90 0	89 3	106 5	108 0	107 3
6 5 0 ,,	73 8	74 10	74 2	90 5	91 10	91 1	108 7	110 3	109 5
6 7 6 ,,	75 2	76 4	75 8	92 3	93 8	92 11	110 8	112 6	111 7
6 10 0 ,,	76 7	77 10	77 2	94 1	95 6	94 9	112 11	114 8	113 10
6 12 6 ,,	78 1	79 3	78 8	95 11	97 4	96 8	115 1	116 11	116 0
6 15 0 ,,	79 7	80 10	80 2	97 8	99 2	98 5	117 3	119 1	118 2
6 17 6 ,,	81 0	82 4	81 8	99 6	101 0	100 3	119 5	121 4	120 4
7 0 0 ,,	82 6	83 10	83 1	101 4	102 10	102 1	121 7	123 6	122 7
7 2 6 ,,	84 0	85 4	84 7	103 1	104 9	103 11	123 10	125 8	124 9
7 5 0 ,,	85 5	86 10	86 1	104 11	106 6	105 8	126 0	127 11	126 11
7 7 6 ,,	86 11	88 4	87 7	106 9	108 5	107 6	128 2	130 1	129 2
7 10 0 ,,	88 5	89 9	89 1	108 6	110 3	109 4	130 4	132 4	131 4
7 12 6 ,,	89 10	91 4	90 6	110 4	112 1	111 2	132 6	134 6	133 6
7 15 0 ,,	91 4	92 9	92 0	112 2	113 11	113 0	134 8	136 9	135 8
7 17 6 ,,	92 10	94 3	93 6	114 0	115 9	114 10	136 10	138 11	137 11
8 0 0 ,,	94 3	95 9	95 0	115 9	117 7	116 8	139 0	141 2	140 1
8 2 6 ,,	95 9	97 3	96 6	117 7	119 5	118 6	141 2	143 4	142 3
8 5 0 ,,	97 3	98 9	97 11	119 5	121 3	120 3	143 4	145 7	144 5
8 7 6 ,,	98 9	100 3	99 5	121 3	123 1	122 2	145 6	147 9	146 8
8 10 0 ,,	100 2	101 9	100 11	123 0	124 11	123 11	147 8	149 11	148 10
8 12 6 ,,	101 8	103 3	102 5	124 10	126 9	125 9	149 10	152 1	151 0
8 15 0 ,,	103 1	104 9	103 11	126 8	128 7	127 7	152 0	154 4	153 2
8 17 6 ,,	104 7	106 3	105 5	128 6	130 5	129 5	154 2	156 6	155 5
9 0 0 ,,	106 1	107 9	106 10	130 3	132 3	131 3	156 4	158 9	157 7
9 2 6 ,,	107 7	109 3	108 4	132 1	134 1	133 1	158 7	160 11	159 9
9 5 0 ,,	109 0	110 9	109 10	133 10	135 11	134 10	160 8	163 2	161 11
9 7 6 ,,	110 6	112 3	111 4	135 8	137 9	136 8	162 11	165 4	164 1
9 10 0 ,,	111 11	113 9	112 10	137 6	139 7	138 6	165 1	167 7	166 4
9 12 6 ,,	113 5	115 3	114 4	139 4	141 5	140 4	167 3	169 9	168 6
9 15 0 ,,	114 11	116 9	115 9	141 1	143 3	142 2	169 5	172 0	170 8
9 17 6 ,,	116 5	118 3	117 3	142 11	145 1	144 0	171 7	174 2	172 10
10 0 0 ,,	117 10	119 9	118 9	144 9	146 11	145 10	173 9	176 5	175 1
10 5 0 ,,	120 10	122 9	121 8	148 4	150 8	149 5	178 1	180 10	179 5
10 10 0 ,,	123 9	125 8	124 8	151 11	154 4	153 1	182 5	185 3	183 10
10 15 0 ,,	126 8	128 8	127 8	155 7	158 0	156 9	186 9	189 8	188 3
11 0 0 ,,	129 8	131 8	130 7	159 2	161 8	160 4	191 1	194 1	192 7
11 5 0 ,,	132 7	134 8	133 7	162 10	165 4	164 0	195 5	198 6	197 0
11 10 0 ,,	135 6	137 8	136 7	166 5	169 0	167 8	199 10	202 11	201 4
12 0 0 ,,	141 5	143 8	142 6	173 8	176 4	174 11	208 6	211 8	210 1

TABLES

Of the Discharge of Gas, in Cubic Feet per Hour, through Pipes of various Diameters and Lengths, at different Pressures.

By Thomas G. Barlow. Extended by Thomas Newbigging.

(*The specific gravity of the gas is taken at* 0·4, *air being* 1.)

The tables are calculated according to the formula given by Professor ole in his valuable article* "On the Motion of Fluids in Pipes," iz.:—

Q = quantity of gas in cubic feet per hour.
l = length of pipe in yards.
d = diameter of pipe in inches.
h = pressure in inches of water.
s = specific gravity of gas, atmospheric air being 1.

$$Q = 1350\, d^2 \sqrt{\frac{h\ d}{s\ l}}$$

–*i.e.*, multiply the pressure in inches of water by the diameter of the ipe, also in inches. Divide the product by the specific gravity of the as multiplied by the length of the pipe in yards. Extract the square oot of the quotient, which root, multiplied by the constant quantity 350, and the square of the diameter of the pipe in inches, gives the umber of cubic feet discharged in one hour.

Example.—It is required to find the number of cubic feet of gas of he specific gravity of 0·400, which will be discharged in one hour rom a pipe 8 inches in diameter, and 1250 yards in length, under a ressure of 15-10ths, or 1½-inches head of water.

Thus—$(h\ d) = 8 \times 1{\cdot}5 = 12$.

$$\left(\sqrt{\frac{h\ d}{s\ l}} = \frac{12}{{\cdot}4 \times 1250}\right) = {\cdot}024,\ \text{the square root being} = {\cdot}1549.$$

$$\left(1350\, d^2 \sqrt{\frac{h\ d}{s\ l}}\right) = 1350 \times 64 \times {\cdot}1549 = 13{,}383\ \text{cubic feet} = Q.$$

Diameter of Pipe, 0·5 Inch.

ength in yards	10.	20.	30.	50.	75.	100.	150.
uantity delivered ith 0·1 in. pressure	37·7	26·7	21·7	16·8	13·8	11·9	9·7
0·2 "	53·4	37·7	30·6	23·8	19·5	16·8	13·8
0·3 "	65·2	46·3	37·7	29·1	23·8	20·7	16·8
0·4 "	75·2	53·3	43·2	33·7	27·5	23·8	19·5
0·5 "	84·3	59·4	48·6	37·4	30·7	26·7	21·7
0·6 "	92·1	65·1	53·3	41·1	33·7	29·0	23·8
0·8 "	106·7	75·4	61·4	47·5	38·8	33·7	27·4
1·0 "	119·1	84·3	68·8	53·3	43·2	37·7	30·8
1·2 "	130·6	92·1	75·2	58·3	47·5	41·1	33·7
1·5 "	146·1	103·2	84·3	65·1	53·3	45·9	37·8
1·8 "	159·9	113·0	92·1	71·5	58·3	50·6	41·1
2·0 "	168·7	119·1	97·2	75·2	61·4	53·3	43·5
2·5 "	188·6	133·3	108·6	84·3	68·8	59·4	48·6

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* See "King's Treatise," Vol. II., p. 374, et seq.

Diameter of Pipe, 0·75 *Inch.*

Length in yards .	10.	20.	30.	50.	75.	100.	150.
Quantity delivered with 0·1 in. pressure	104·3	73·8	60·0	46·6	37·9	32·9	26·9
0·2 ,,	147·5	104·3	84·9	65·8	53·7	46·6	37·9
0·3 ,,	179·9	126·8	104·3	80·9	65·8	57·0	46·6
0·4 ,,	207·3	146·5	119·9	93·2	75·9	65·8	53·8
0·5 ,,	232·3	164·0	133·6	103·2	84·2	73·8	60·0
0·6 ,,	254·3	179·9	146·5	113·9	92·6	79·7	65·3
0·8 ,,	293·8	207·3	169·3	131·3	107·0	92·6	75·9
1·0 ,,	328·8	232·3	189·8	146·5	119·9	103·2	84·2
1·2 ,,	359·9	254·3	207·3	160·9	131·3	113·9	92·6
1·5 ,,	402·4	284·0	232·3	179·9	146·5	126·8	103·2
1·8 ,,	441·1	311·3	254·3	192·2	160·9	138·9	113·9
2·0 ,,	464·7	328·8	268·0	207·3	169·3	146·5	119·9
2·5 ,,	519·4	367·5	299·9	232·2	189·8	164·0	133·6

Diameter of Pipe, 1 *Inch.*

Length in yards .	10.	20.	30.	50.	75.	100.	150.
Quantity delivered with 0·1 in. pressure	214·0	151·0	124·0	95·0	78·0	67·0	55·0
0·2 ,,	302·0	214·0	175·0	135·0	110·0	95·0	78·0
0·3 ,,	368·5	260·5	214·0	165·0	135·0	117·0	95·0
0·4 ,,	426·6	301·0	245·7	190·0	156·0	135·0	110·0
0·5 ,,	476·5	337·5	274·0	213·3	172·8	151·0	123·0
0·6 ,,	522·4	368·5	301·0	233·5	190·3	164·7	135·0
0·8 ,,	603·4	426·6	348·3	270·0	220·0	190·3	155·2
1·0 ,,	675·0	476·5	388·8	301·0	245·7	213·3	172·8
1·2 ,,	738·4	522·4	426·6	329·4	270·0	233·5	190·3
1·5 ,,	826·2	584·5	476·5	368·5	301·0	260·5	213·3
1·8 ,,	904·5	639·9	522·4	405·0	329·4	286·2	233·5
2·0 ,,	954·4	675·0	550·8	426·6	348·3	301·0	245·7
2·5 ,,	1066·5	754·6	615·6	476·5	388·8	337·5	274·0

Diameter of Pipe, 1·25 *Inches.*

Length in yards .	25.	50.	75.	100.	150.	200.	300.
Quantity delivered with 0·1 in. pressure	236·0	167·0	137·0	118·0	96·0	84·0	68·0
0·2 ,,	333·0	236·0	192·0	167·0	137·0	118·0	96·0
0·3 ,,	407·1	289·0	236·0	205·0	167·0	144·0	118·0
0·4 ,,	470·3	333·2	272·1	236·0	192·0	167·0	137·0
0·5 ,,	527·3	371·2	303·7	263·6	215·1	187·0	152·0
0·6 ,,	575·8	407·1	333·2	286·8	235·8	203·9	166·6
0·8 ,,	666·5	470·3	383·9	333·2	272·1	235·8	192·3
1·0 ,,	744·6	527·3	430·3	371·2	303·7	263·6	215·1
1·2 ,,	816·3	575·8	470·3	407·1	333·2	286·8	235·8
1·5 ,,	913·3	645·4	527·3	455·6	371·2	322·7	263·6
1·8 ,,	999·8	706·4	575·8	499·9	407·1	352·2	286·8
2·0 ,,	1054·6	744·6	607·5	527·3	430·3	371·2	303·7
2·5 ,,	1179·1	833·2	679·2	588·5	480·9	415·5	339·6

Diameter of Pipe, 1·5 *Inches.*

ength in yards .	25.	50.	75.	100.	150.	200.	300.
uantity delivered ith 0·1 in. pressure	374·0	264·0	215·0	187·0	152·0	132·0	107·0
0·2 „	528·0	374·0	304·0	264·0	215·0	187·0	152·0
0·3 „	648·9	458·0	374·0	322·0	264·0	229·0	187·0
0·4 „	741·1	525·4	428·2	374·0	304·0	264·0	215·0
0·5 „	829·2	586·2	479·9	418·1	339·5	295·0	239·0
0·6 „	911·2	643·9	525·4	455·6	370·5	321·9	261·2
0·8 „	1050·9	741·1	607·5	525·4	428·2	370·5	303·7
1·0 „	1175·5	829·2	677·3	586·2	479·9	418·1	339·5
1·2 „	1287·9	911·2	741·1	643·9	525·4	455·6	370·5
1·5 „	1439·7	1017·5	829·2	719·8	586·2	507·2	418·1
1·8 „	1576·4	1114·7	911·2	789·1	643·9	555·8	455·6
2·0 „	1661·5	1175·5	959·8	829·2	677·3	586·2	479·9
2·5 „	1858·9	1315·2	1072·2	929·4	759·3	656·1	534·6

Diameter of Pipe, 2 *Inches.*

ength in yards .	50.	75.	100.	150.	200.	300.	500.
uantity delivered ith 0·1 in. pressure	540	441	381	311	270	220	170
0·2 „	763	623	540	441	381	311	241
0·3 „	934	763	665	540	468	381	296
0·4 „	1080	880	761	623	540	441	341
0·5 „	1204	983	858	697	604	492	381
0·6 „	1318	1080	934	761	659	540	416
0·8 „	1523	1242	1080	880	761	621	481
1·0 „	1706	1393	1204	983	858	697	540
1·2 „	1868	1523	1318	1080	984	761	589
1·5 „	2090	1706	1474	1204	1042	858	659
1·8 „	2290	1868	1620	1318	1145	934	724
2·0 „	2414	1971	1706	1393	1204	983	761
2·5 „	2700	2203	1906	1555	1350	1102	853

Diameter of Pipe, 2·5 *Inches.*

Length in yards .	50.	75.	100.	150.	200.	300.	500.
Quantity delivered with 0·1 in. pressure	943	770	667	545	471	335	298
0·2 „	1335	1090	943	770	667	545	421
0·3 „	1628	1335	1172	943	819	667	516
0·4 „	1882	1540	1333	1090	943	770	596
0·5 „	2109	1721	1485	1215	1055	861	667
0·6 „	2303	1882	1628	1333	1148	943	731
0·8 „	2666	2177	1882	1540	1333	1088	844
1·0 „	2978	2430	2109	1721	1485	1215	943
1·2 „	3265	2666	2303	1882	1628	1333	1029
1·5 „	3653	2978	2582	2109	1823	1485	1148
1·8 „	3999	3265	2827	2303	2000	1628	1266
2·0 „	4219	3443	2978	2430	2109	1721	1333
2·5 ..	4717	3848	3333	2717	2354	1924	1485

Diameter of Pipe, 3 Inches.

Length in yards.	100.	150.	250.	500.	750.	1000.	1250.
Quantity delivered with 0·1 in. pressure	1,054	859	666	471	384	333	298
0·2 "	1,440	1,214	942	666	543	471	375
0·3 "	1,823	1,487	1,153	815	666	576	529
0·4 "	2,102	1,713	1,332	942	768	666	596
0·5 "	2,345	1,920	1,482	1,054	859	744	666
0·6 "	2,576	2,102	1,628	1,152	942	815	789
0·8 "	2,965	2,430	1,882	1,324	1,081	942	845
1·0 "	3,317	2,709	2,102	1,482	1,215	1,052	942
1·2 "	3,645	2,965	2,296	1,628	1,324	1,152	1,030
1·5 "	4,070	3,317	2,576	1,823	1,482	1,288	1,152
1·8 "	4,459	3,645	2,819	1,993	1,628	1,409	1,262
2·0 "	4,702	3,839	2,965	2,102	1,718	1,482	1,324
2·5 "	5,261	4,289	3,317	2,345	1,920	1,652	1,482

Diameter of Pipe, 4 Inches.

Length in yards.	100.	250.	500.	750.	1000.	1250.	1500.
Quantity delivered with 0·1 in. pressure	2,160	1,366	966	788	683	611	557
0·2 "	3,054	1,932	1,366	1,114	966	864	788
0·3 "	3,737	2,366	1,673	1,366	1,183	1,058	966
0·4 "	4,320	2,722	1,932	1,576	1,366	1,222	1,114
0·5 "	4,817	3,046	2,160	1,761	1,526	1,366	1,245
0·6 "	5,270	3,346	2,354	1,932	1,672	1,496	1,366
0·8 "	6,091	3,845	2,722	2,225	1,932	1,728	1,576
1·0 "	6,826	4,320	3,046	2,484	2,160	1,932	1,761
1·2 "	7,474	4,730	3,346	2,722	2,354	2,115	1,922
1·5 "	8,359	5,270	3,737	3,046	2,635	2,354	2,160
1·8 "	9,158	5,789	4,082	3,346	2,894	2,592	2,354
2·0 "	9,655	6,091	4,320	3,521	3,046	2,722	2,484
2·5 "	10,800	6,826	4,817	3,931	3,413	3,046	2,786

Diameter of Pipe, 5 Inches.

Length in yards.	100.	250.	500.	750.	1000.	1250.	1500.
Quantity delivered with 0·1 in. pressure	3,540	2,245	1,587	1,296	1,122	1,000	910
0·2 "	5,005	3,174	2,245	1,832	1,587	1,414	1,296
0·3 "	6,514	3,888	2,748	2,245	1,943	1,732	1,575
0·4 "	7,526	4,759	3,174	2,592	2,245	2,000	1,820
0·5 "	8,438	5,333	3,773	2,888	2,508	2,236	1,934
0·6 "	9,214	5,839	4,118	3,174	2,748	2,449	2,245
0·8 "	10,665	6,750	4,759	3,881	3,174	2,828	2,596
1·0 "	11,914	7,526	5,333	4,354	3,773	3,174	2,877
1·2 "	13,061	8,235	5,839	4,759	4,118	3,679	3,375
1·5 "	14,614	9,214	6,514	5,333	4,590	4,118	3,540
1·8 "	15,998	10,125	7,156	5,839	5,063	4,528	4,118
2·0 "	16,875	10,665	7,526	6,143	5,333	4,759	4,354
2·5 "	18,866	11,914	8,438	6,885	5,940	5,333	4,860

Diameter of Pipe, 6 *Inches.*

Length in yards.	**250.**	**500.**	750.	1000.	1250.	1500.	1750.
Quantity delivered with 0·1 in. pressure	3,770	2,660	2,170	1,880	1,680	1,530	1,420
0·2 ”	5,320	3,770	3,130	2,660	2,370	2,170	2,010
0·3 ”	6,530	4,620	3,770	3,270	2,920	2,660	2,460
0·4 ”	7,540	5,320	4,340	3,770	3,360	3,060	2,840
0·5 ”	8,408	5,970	4,860	4,210	3,770	3,430	3,180
0·6 ”	9,185	6,512	5,320	4,620	4,130	3,770	3,460
0·8 ”	10,643	7,528	6,124	5,320	4,740	4,340	4,020
1·0 ”	11,858	8,408	6,853	5,929	5,320	4,860	4,500
1·2 ”	13,025	9,185	7,528	6,512	5,832	5,297	4,929
1·5 ”	14,580	10,303	8,408	7,290	6,512	5,970	5,500
1·8 ”	15,941	11,275	9,185	7,970	7,139	6,512	6,026
2·0 ”	16,816	11,858	9,720	8,408	7,528	6,853	6,360
2·5 ”	18,808	13,268	10,838	9,380	8,408	7,679	7,096

Diameter of Pipe, 7 *Inches.*

Length in yards.	250.	500.	750.	1000.	1250.	1500.	1750.
Quantity delivered with 0·1 in. pressure	5,560	3,920	3,200	2,780	2,470	2,270	2,100
0·2 ”	7,840	5,560	4,510	3,920	3,500	3,200	2,960
0·3 ”	9,600	6,800	5,560	4,800	4,300	3,920	3,640
0·4 ”	11,120	7,840	6,400	5,560	4,940	4,540	4,200
0·5 ”	12,370	8,750	7,180	6,200	5,560	5,060	4,680
0·6 ”	13,554	9,585	7,840	6,800	6,080	5,560	5,130
0·8 ”	15,611	11,047	8,996	7,840	7,020	6,400	5,930
1·0 ”	17,463	12.370	10,054	8,732	7,840	7,180	6,610
1·2 ”	19,170	13,554	11,047	9,585	8,533	7,805	7,210
1·5 ”	21,433	15,148	12,370	10,716	9,585	8,750	8,120
1·8 ”	23,477	16,597	13,554	11,709	10,452	9,855	8,864
2·0 ”	24,740	17,463	14,288	12,370	11,047	10,054	9,360
2·5 ”	27,651	19,567	15,942	13,825	12,370	11,292	10,452

Diameter of Pipe, 8 *Inches.*

Length in yards.	250.	500.	750.	1000.	1250.	1500.	**1750.**
Quantity delivered with 0·1 in. pressure	7,760	5,470	4,470	3,880	3,460	3,160	2,920
0·2 ”	10,940	7,760	6,310	5,470	4,880	4,470	4,130
0·3 ”	13,400	9,450	7,760	6,700	5,980	5,470	5,050
0·4 ”	15,520	10,940	8,940	7,760	6,920	6,320	5,840
0·5 ”	17,280	12,200	9,900	8,640	7,760	7,020	6,520
0·6 ”	18,922	13,383	10,940	9,450	8,480	7,760	7,150
0·8 ”	21,851	15,379	12,614	10,940	9,780	8,940	8,260
1·0 ”	24,365	17,280	14,083	12,182	10,940	9,900	9,237
1·2 ”	26,767	18,922	15,379	13,383	11,923	10,886	10,109
1·5 ”	29,894	21,082	17,280	14,947	13,383	12,200	11,300
1·8 ”	32,746	23,155	18,922	16,330	14,602	13,383	12,355
2·0 ”	34,560	24,365	19,872	17,280	15,379	14,083	13,040
2·5 ”	38,621	27,302	22,291	19,267	17,280	15,725	14,602

Diameter of Pipe, 9 *Inches.*

Length in yards.	250.	500.	750.	1000.	1250.	1500.	1750.
Quantity delivered with 0·1 in. pressure	10,400	7,380	6,350	5,200	4,650	4,250	3,950
0·2 „	14,760	10,400	8,500	7,380	6,480	6,000	5,620
0·3 „	18,000	12,780	10,400	9,000	8,300	7,380	6,800
0·4 „	20,800	14,760	12,700	10,400	9,300	8,500	7,900
0·5 „	23,182	16,500	13,420	11,900	10,400	9,680	8,800
0·6 „	25,369	17,933	14,760	12,780	11,400	10,400	9,650
0·8 „	29,306	20,667	16,938	14,760	13,100	12,000	11,050
1·0 „	32,805	23,182	18,918	16,403	14,760	13,420	12,380
1·2 „	35,867	25,369	20,667	17,933	16,064	14,653	13.559
1·5 „	40,131	28,409	23,182	20,011	17,933	16,500	15,200
1·8 „	43,959	31,055	25,369	21,979	19,683	17,933	16,621
2·0 „	46,364	32,805	26,681	23,182	20,667	18,918	17,600
2·5 „	51,832	36,632	29,853	25,916	23,182	21,105	19,574

Diameter of Pipe, 10 *Inches.*

Length in yards.	500.	750.	1000.	1250.	1500.	1750.	2000.
Quantity delivered with 0·1 in. pressure	9,560	7,800	6,750	6,050	5,520	5,100	4,780
0·2 „	13,500	11,040	9,560	8,520	7,800	7,300	6,750
0·3 „	16,500	13,500	11,700	10,520	9,560	8,850	8,259
0·4 „	19,120	15,600	13,500	12,100	11,040	10,200	9,560
0·5 „	21,300	17,400	15,050	13,500	12,380	11,400	10 650
0·6 „	23,355	19,120	16,500	14,800	13,500	12,500	11,650
0·8 „	27,000	22,005	19,120	17,050	15,600	14,400	13,500
1·0 „	30,105	24,570	21,330	19,120	17,400	16,150	15,050
1·2 „	32,940	27,000	23,355	20,911	19,035	17,550	16,578
1·5 „	36,855	30,105	26,055	23,355	21,300	19,600	18,500
1·8 „	40,500	32,940	28.620	25,515	23,355	21,600	20,250
2·0 „	42,660	34,830	30,105	27,000	24,570	22,800	21,300
2·5 „	47,655	38,880	33,750	30,105	27,540	25,501	23,760

Diameter of Pipe, 12 *Inches.*

Length in yards.	500.	750.	1000.	1250.	1500.	1750.	2000.
Quantity delivered with 0·1 in. pressure	15,100	12,300	10,700	9,550	8,700	8,050	7,550
0·2 „	21,400	17,400	15,100	13,450	12,300	11,350	10,700
0·3 „	26,100	21,400	19,500	16,500	15,100	13,880	13,050
0·4 „	30,200	24,600	21,400	19,100	17,400	16,100	15,100
0·5 „	33,600	27,500	23,800	21,400	19,440	18,050	16,800
0·6 „	36,741	30,200	26,100	23,300	21,400	19,800	19,500
0·8 „	42,573	34,603	30,200	26,900	24,600	22,700	21,400
1·0 „	47,433	38,880	33,631	30,200	27,500	25,450	23,800
1·2 „	52,099	42,573	36,741	32,853	30,112	27,799	26,049
1·5 „	58,320	47,433	41,212	36,741	33,600	31,250	29,250
1·8 „	63,763	52,099	45,100	40,396	36,741	34,020	31,881
2·0 „	67,262	54,820	47,433	42,573	38,880	36,100	33,600
2·5 „	75,232	61,430	53,071	47,433	43,351	40,240	37,519

Diameter of Pipe, 14 *Inches.*

ength in yards.	500.	750.	1000.	1250.	1500.	1750.	2000.
uantity delivered ith 0·1 in. pressure	2,100	18,100	15,600	13,950	12,750	11,800	11,050
0·2 „	31,250	25,500	22,100	19,800	18,100	16,700	15,600
0·3 „	38,400	31,200	27,100	24,250	22,100	20,500	19,200
0·4 „	44,200	36,200	31,300	27,900	25,560	23,600	22,100
0·5 „	49,400	40,460	35,000	31,200	28,500	26,460	24,700
0·6 „	54,216	44,200	38,400	31,300	31,200	28,900	27,100
0·8 „	62,445	51,067	44,200	39,600	36,200	33,400	31,200
1·0 „	69,854	57,158	49,480	44,200	40,400	37,300	35,000
1·2 „	76,681	62,445	54,216	48,421	44,188	40,986	38,340
1·5 „	85,730	69,854	60,593	54,216	49,400	45,700	42,600
1·8 „	93,906	76,681	66,414	59,270	54,216	50,009	46,834
2·0 „	98,980	80,708	69,854	62,445	57,158	52,920	49,400
2·5 „	110,602	90,228	78,268	69,854	63,768	59,005	55,801

Diameter of Pipe, 15 *Inches.*

ength in yards.	500.	750.	1000.	1250.	1500.	1750.	2000.
uantity delivered ith 0·1 in. pressure	26,300	21,400	18,600	16,600	15,200	14,000	13,150
0·2 „	37,200	30,100	26,300	23,500	21,400	19,900	18,600
0·3 „	45,500	37,200	32,250	28,750	26,300	24,300	22,750
0·4 „	52,600	42,800	37,200	33,200	30,400	28,000	26,300
0·5 „	58,700	48,000	41,600	37,200	34,000	31,400	29,350
0·6 „	64,395	52,600	45,500	40,700	37,200	34,450	32,250
0·8 „	74,115	60,750	52,600	47,000	42,800	39,800	37,200
1·0 „	82,923	67,736	58,623	52,600	48,000	44,400	41,600
1·2 „	91,125	74,115	64,395	57,408	52,548	48,600	45,562
1·5 „	101,756	82,923	71,983	64,395	58,700	54,300	50,800
1·8 „	111,476	91,125	78,914	70,470	64,395	59,585	55,586
2·0 „	117,551	95,985	82,923	74,115	67,734	62,800	58,700
2·5 „	131,523	107,223	92,947	82,923	75,937	70,166	65,610

Diameter of Pipe, 16 *Inches.*

ength in yards.	500.	750.	1000.	1250.	1500.	1750.	2000.
Quantity delivered ith 0·1 in. pressure	31,000	25,250	21,850	19,550	17,850	16,550	15,500
0·2 „	43,700	35,700	31,000	27,700	25,250	23,400	21,850
0·3 „	53,600	43,700	38,100	34,000	31,000	28,700	26,800
0·4 „	62,000	50,500	43,700	39,100	35,700	33,100	31,000
0·5 „	69,120	56,600	49,000	43,700	39,900	37,150	34,560
0·6 „	75,683	62,000	53,600	47,900	43,700	38,100	40,700
0·8 „	87,402	71,193	62,000	55,400	50,500	46,800	43,700
1·0 „	97,459	79,488	69,120	62,000	56,600	52,400	49,000
1·2 „	107,066	87,402	75,686	67,703	61,516	57,024	53,583
1·5 „	119,577	97,459	84,326	75,686	69,120	63,900	60,100
1·8 „	130,982	107,066	92,620	82,944	75,686	70,087	65,318
2·0 „	138,210	112,665	97,459	87,402	79,488	74,300	69,120
2·5 „	154,483	126,144	109,209	97,459	89,164	82,598	77,063

Diameter of Pipe, 18 *Inches.*

Length in yards. ..	500.	750.	1000.	1500.	2000.	2500.	3000.
Quantity delivered with 0·1 in. pressure	41,400	33,800	29,400	23,900	20,700	18,400	16,900
0·2 „	58,800	47,800	41,400	33,800	29,400	26,200	23,900
0·3 „	71,800	58,800	50,800	41,400	35,900	32,100	29,400
0·4 „	82,800	67,600	58,800	47,800	41.400	36,800	33,800
0·5 „	92,600	75,700	65,600	53,500	46,300	41,400	37,850
0·6 „	101,476	82,800	71,800	58,800	50,800	45,400	41,400
0·8 „	117,223	95,790	82,800	67,600	58,800	52,300	47,800
1·0 „	131,220	106,725	92,728	75,700	65,600	58,800	53,500
1·2 „	143,467	117,223	101,476	82,668	71,733	64,254	58,611
1·5 „	161,400	131,220	113,636	92,728	80,000	71,800	65,600
1·8 „	175,834	143,467	124,221	101,476	87,917	78,782	71,733
2·0 „	185,457	151,340	131,220	106,725	92,728	82,800	75,700
2·5 „	207,327	169,273	146,529	119,410	103,663	92,728	84,500

Diameter of Pipe, 20 *Inches.*

Length in yards. .	500.	750.	1000.	1500.	2000.	2500.	3000.
Quantity delivered with 0·1 in. pressure	54,000	44,000	38,250	31,200	27,000	24,200	22,000
0·2 „	76,500	62,400	54,000	44,000	38,250	34,200	31,200
0·3 „	93,500	76,500	66,100	54,000	46,750	41,800	38,250
0·4 „	108,000	88,000	76,500	62,400	54,000	48,400	44,000
0·5 „	120,500	98,800	85,300	69,800	62,250	54,000	49,400
0·6 „	131,760	108,000	93,500	76,500	66,100	59,100	54,000
0·8 „	152,280	124,200	108,000	88,000	76,500	68,400	62,400
1·0 „	170,640	139,320	120,420	98,800	85,300	76,500	69,800
1·2 „	186,840	152,280	131,760	108,000	93,420	83,646	76,140
1·5 „	208,980	170,640	147,420	120,420	102,300	93,500	85,300
1·8 „	228,960	186·840	162,000	131,760	114,480	102,060	93,420
2·0 „	241,380	197,100	170,640	139,320	120,420	108,000	98,800
2·5 „	270,000	220,320	190,620	155,520	135,000	120,420	110,200

Diameter of Pipe, 22 *Inches.*

Length in yards. ..	500.	750.	1000.	1500.	2000.	2500.	3000.
Quantity delivered with 0·1 in. pressure	68,600	56,000	48,400	39,600	34,300	30,700	28,000
0·2 „	96,800	79,200	68,600	56,000	48,000	43,400	39,600
0·3 „	118,800	96,800	84,000	68,600	59,400	53,300	48,400
0·4 „	137,200	112,000	96,800	79,200	68,600	61,400	56,000
0·5 „	153,500	122,500	108,200	88,600	76,800	68,400	61,200
0·6 „	168,577	137,200	118,800	96,800	84,000	75,000	68,600
0·8 „	193,406	158,122	137,200	112,000	96,800	86,500	79,200
1·0 „	216,275	176,418	152,895	122,500	108,200	96,800	88,600
1·2 „	237,184	193,406	168,577	136,560	118,265	105,850	96,703
1·5 „	265,280	216,275	187,525	152,895	132,000	118,800	108,200
1·8 „	290,697	237,184	203,860	168,577	145,054	130,026	118,265
2·0 „	306,444	249,598	216,275	176,418	152,895	137,200	122,500
2·5 „	342,381	279,655	242,280	197,326	171,190	152,895	140,000

Diameter of Pipe, 24 Inches.

Length in yards. .	500.	750.	1000.	1500.	2000.	2500.	3000.
Quantity delivered with 0·1 in. pressure	84,000	68,600	59,500	48,500	42,000	37,500	34,300
0·2 ,,	119,000	97,000	84,000	68,600	59,500	53,400	48,500
0·3 ,,	145,500	119,000	103,000	84,000	72,700	65,200	59,500
0·4 ,,	168,000	137,200	119,000	97,000	84,000	75,000	68,600
0·5 ,,	187,500	155,000	135,600	108,600	93,800	84,000	77,500
0·6 ,,	208,396	168,000	145,000	119,000	103,000	92,000	84,000
0·8 ,,	240,900	196,655	168,000	137,200	119,000	106,000	97,000
1·0 ,,	269,049	219,283	189,734	155,000	135,600	119,000	108,600
1·2 ,,	294,710	240,900	208,396	170,294	146,966	131,414	120,450
1·5 ,,	329,702	269,049	233,280	189,734	163,000	145,500	135,600
1·8 ,,	360,806	294,710	255,052	208,396	180,403	161,585	146,966
2·0 ,,	380,946	311,040	269,049	219,283	189,734	168,000	155,000
2·5 ,,	425,347	347,587	300,931	245,721	212,284	189,734	172,000

Diameter of Pipe, 26 Inches.

Length in yards. .	750.	1000.	1500.	2000.	2500.	3000.	4000.
Quantity delivered with 0·1 in. pressure	85,000	73,500	60,000	52,000	46,500	42,500	36,750
0·2 ,,	120,000	104,000	85,000	73,500	65,800	60,000	52,000
0·3 ,,	147,000	127,000	104,000	90,000	80,600	73,500	63,500
0·4 ,,	170,000	147,000	120,000	104,000	93,000	85,000	73,500
0·5 ,,	189,000	165,000	134,000	116,000	104,000	94,500	82,500
0·6 ,,	208,000	180,000	147,000	127,000	114,000	104,000	90,000
0·8 ,,	240,013	208,000	170,000	147,000	132,000	120,000	104,000
1·0 ,,	268,304	232,621	189,000	165,000	147,000	134,000	116,000
1·2 ,,	293,857	254,615	208,072	179,782	160,617	146,928	126,851
1·5 ,,	328,536	284,731	232,621	201,000	180,000	165,000	142,000
1·8 ,,	360,385	312,109	254,615	220,666	197,121	179,782	156,054
2·0 ,,	379,641	328,536	268,304	232,621	208,000	189,000	165,000
2·5 ,,	424,359	367,777	300,245	260,091	232,621	213,000	184,000
3·0 ,,	465,334	402,456	328,536	284,731	254,615	232,621	201,000

Diameter of Pipe, 28 Inches.

Length in yards. .	1000.	1500.	2000.	2500.	3000.	4000.	5000.
Quantity delivered with 0·5 in. pressure	198,000	161,000	140,000	125,000	114,500	99,000	88,600
0·6 ,,	216,866	176,752	153,362	136,533	124,891	107,956	96,314
0·8 ,,	249,782	204,271	176,752	157,701	143,942	124,891	111,978
1·0 ,,	280,000	229,000	198,000	177,000	161,000	140,000	125,000
1·2 ,,	306,724	249,782	216,866	193,687	176,752	153,362	136,533
1·5 ,,	342,921	280,000	241,000	216,000	198,000	171,000	153,500
1·8 ,,	375,626	306,724	265,658	237,081	216,866	187,336	167,227
2·0 ,,	395,841	322,812	280,000	250,000	229,000	198,000	177,200
2·5 ,,	442,411	360,914	313,074	280,000	255,000	222,000	198,000
3·0 ,,	484,747	395,841	342,921	306,724	280,000	241,000	216,000

Diameter of Pipe, 30 *Inches.*

Length in yards.	1000.	2000.	3000.	4000.	5000.	7500.	10000.
Quantity delivered with 0·5 in. pressure	234,000	166,000	135,000	117,000	105,000	86,000	74,500
0·6 „	257,580	182,250	148,230	128,790	115,182	94,041	81,405
0·8 „	296,460	210,195	171,315	148,230	132,435	108,135	94,041
1·0 „	332,000	234,000	192,000	166,000	149,000	121,500	105,000
1·2 „	364,500	257,580	210,195	182,250	162,810	132,435	115,182
1·5 „	407,025	287,000	234,000	203,000	182,000	149,000	128,500
1·8 „	445,905	315,657	257,580	222,345	199,260	162,810	140,940
2·0 „	470,205	331,695	270,000	234,000	210,000	172,000	149,000
2·5 „	526,095	371,790	303,750	263,000	234,000	192,000	166,000
3·0 „	575,910	407,025	331,695	287,955	257,000	210,000	182,000
4·0 „	664,605	470,205	383,910	331,695	298,000	243,000	210,000

Diameter of Pipe, 36 *Inches.*

Length in yards.	1000.	2000.	3000.	4000.	5000.	7500.	10000.
Quantity delivered with 0·5 in. pressure	370,915	262,440	213,451	185,457	165,862	135,419	117,223
0·6 „	405,907	286,934	234,446	202,953	181,783	148,366	127,720
0·8 „	468,892	330,674	271,018	234,446	209,952	171,285	148,366
1·0 „	530,000	370,000	303,000	265,000	234,000	192,000	166,000
1·2 „	573,868	405,907	330,674	286,934	257,016	209,952	181,783
1·5 „	642,103	456,000	372,000	322,000	288,000	234,900	204,000
1·8 „	703,339	496,886	405,907	351,669	314,928	257,016	222,199
2·0 „	741,830	524,880	428,000	372,000	332,000	271,000	234,000
2·5 „	829,310	586,116	477,640	416,000	372,000	303,000	265,000
3·0 „	908,042	642,103	524,880	454,546	407,000	332,000	288,000
4·0 „	1,049,760	742,180	605,361	524,880	468,892	384,000	332,000

The foregoing tables are calculated upon the basis of the specific gravity of the gas being ·400. The quantity of gas of any other specific gravity discharged may be ascertained by multiplying the quantity indicated in the table by ·6325 (the square root of ·400), and dividing by the square root of the specific gravity of the other gas.

Example.—If a 12-inch pipe, 1000 yards long, discharges 23,800 cubic feet of gas per hour, specific gravity ·400 at ·5 pressure, how much gas will the same pipe discharge, at the same pressure when the specific gravity is ·560?

$$\frac{23{,}800 \times \cdot 6325}{\cdot 7483} = 20{,}116 \text{ cubic feet.—\textit{Answer}.}$$

The quantity of gas discharged at any other pressure may be ascertained by multiplying the quantity indicated in the table by the square root of the new pressure, and dividing by the square root of the original pressure.

Example.—If a quantity of gas equal to 23,355 cubic feet is discharged in one hour at a pressure of 1·2 inches, what quantity will *be discharged* through the same pipe at 2·2 inches pressure?

$$\frac{23{,}355 \times 1\cdot 4832}{1\cdot 0954} = 31{,}623 \text{ cubic feet.—Answer.}$$

To facilitate these calculations, tables are annexed of the square roots of specific gravities from ·350 to ·700, rising ·005 at a time; and of the square roots of pressures from 1-10th of an inch to 4 inches, rising 1-10th at a time.

TABLE.

Square Root of the Specific Gravity of Gas from ·350 to ·700.

Specific Gravity.	Square Root.	Specific Gravity.	Square Root.	Specific Gravity.	Square Root.	Specific Gravity.	Square Root.	Specific Gravity.	Square Root.
·350	·5916	·425	·6519	·495	·7035	·565	·7517	·635	·7969
.355	·5958	·430	·6557	·500	·7071	·570	·7549	·640	·8000
·360	·6000	·435	·6595	·505	·7106	·575	·7583	·645	·8031
·365	·6041	·440	·6633	·510	·7141	·580	·7616	·650	·8062
·370	·6083	·445	·6671	·515	·7176	·585	·7648	·655	·8093
·375	·6124	·450	·6708	·520	·7212	·590	·7681	·660	·8124
·380	·6164	·455	·6745	·525	·7246	·595	·7713	·665	·8155
·385	·6205	·460	·6782	·530	·7280	·600	·7746	·670	·8185
·390	·6245	·465	·6819	·535	·7314	·605	·7778	·675	·8216
.395	·6285	·470	·6856	·540	·7348	·610	·7810	·680	·8246
·400	·6325	·475	·6892	·545	·7382	·615	·7842	·685	·8276
·405	.6364	·480	·6928	·550	·7416	·620	·7874	·690	·8306
·410	·6403	·485	·6964	·555	·7449	·625	·7905	·695	·8337
·415	·6442	·490	·7000	·560	·7483	·630	·7937	·700	·8367
·420	.6481								

TABLE.

Square Root of Pressures, rising by Tenths of an Inch, from One-Tenth to Four Inches.

Inches and Tenths.	Square Root.	Inches and Tenths.	Square Root.	Inches and Tenths.	Square Root.
1-10th.	·3162	1·5-10ths.	1·2251	2·8-10ths.	1·6733
2-10ths.	·4472	1·6 ,,	1·2649	2·9 ,,	1·7029
3 ,,	·5477	1·7 ,,	1·3038	3 inches.	1·7320
4 ,,	·6324	1·8 ,,	1·3416	3·1-10th.	1·7606
5 ,,	·7071	1·9 ,,	1·3784	3·2-10ths.	1·7888
6 ,,	·7745	2 inches.	1·4142	3·3 ,,	1·8165
7 ,,	·8366	2·1-10th.	1·4491	3·4 ,,	1·8439
8 ,,	·8944	2·2-10ths.	1·4832	3·5 ,,	1·8708
9 ,,	·9487	2·3 ,,	1·5165	3·6 ,,	1·8973
1 inch.	1·0000	2·4 ,,	1·5491	3·7 ,,	1·9235
1·1-10th.	1·0488	2·5 ,,	1·5811	3·8 ,,	1·9493
1·2-10ths.	1·0954	2·6 ,,	1·6123	3·9 ,,	1·9748
1·3 ,,	1·1401	2·7 ,,	1·6431	4 inches.	2·0000
1·4 ,,	1·1832				

Should it be required to find the pressure in inches of water to discharge a certain quantity of gas of given specific gravity in an hour, through a pipe the dimensions of which are known, the formula is—

$$h = \frac{Q^2 s l}{(1350)^2 d^5}$$

i.e., **multiply the square of the number of cubic feet of gas to be dis-**

charged in one hour by the specific gravity of the gas, and by the length of the pipe in yards; divide the product by the square of the constant number 1350, multiplied by the diameter in inches raised to the fifth power, and the quotient is the pressure.

Example.—It is required to find the pressure in inches of water to discharge in an hour 12,000 cubic feet of gas, specific gravity ·5, through a pipe 8 inches in diameter and 1900 yards long. Thus—

$$\frac{Q^2 \times s \times l}{1350^2 \times d^5} = \frac{144{,}000{,}000 \times {\cdot}5 \times 1900}{1{,}822{,}500 \times 32{,}768} \times \frac{136{,}800{,}000{,}000}{59{,}719{,}680{,}000} = \left\{\begin{array}{l}2{\cdot}3 \text{ inches,}\\ \text{nearly.}\end{array}\right.$$

If the diameter of a pipe is required which will discharge a given quantity of gas under a given pressure, we have the formula—

$$d = \sqrt[5]{\frac{Q^2\,s\,l}{(1350)^2\,h}}$$

This can easily be calculated by a table of logarithms—*i.e.*

$$\text{log. } d = \tfrac{1}{5}\,(2 \text{ log. } Q + \text{log. } s. + \text{log. } l. - 2 \text{ log. } 1350 + \text{log. } h.)$$

Example.—It is required to find the diameter of a pipe 1240 yards long, to discharge 48,000 cubic feet of gas, of the specific gravity ·4, in one hour, with a pressure of 2 inches. Thus—

$$\begin{array}{lcr}
2 \text{ log. } Q = 2 \text{ log. } 48{,}000 \ldots\ldots & = & 9{\cdot}3624824 \\
\text{log. } s = \text{log. } {\cdot}4 \ldots\ldots & = & 1{\cdot}6020600 \\
\text{log. } l = \text{log. } 1240 \ldots\ldots & = & 3{\cdot}0934217 \\
\hline
 & & 12{\cdot}0579641 \\
\left.\begin{array}{l} 2 \text{ log. } 1350 \qquad = 6{\cdot}2606676 \\ \text{log. } h = \text{log. } 2 = 0{\cdot}3010300 \end{array}\right\} \ldots\ldots & = & 6{\cdot}5616976 \\
\hline
 & & 5)\,5{\cdot}4962665 \\
\hline
\text{log. } d \ldots\ldots\ldots\ldots & = & 1{\cdot}0992533
\end{array}$$

Therefore $d = 13$ inches, nearly.

The following axioms are worth remembering:—

1. The discharge of gas will be doubled when the length of the pipe is only one-fourth of any of the lengths given in the tables.
2. The discharge of gas will be only one-half when the length of the pipe is four times greater than the lengths given in the tables.
3. The discharge of gas will be doubled by the application of four times the pressure.

Handy rule for finding (approximately) the Content of a Pipe in Gallons and Cubic Feet.

Rule.—Multiply the square of the diameter of the pipe in inches by the length in yards, and divide by 10 for gallons, and by 60 for cubic feet.

Example.—A pipe is 6 in. diameter and 400 yards long, what is the *content ?* then

$$6^2 \times 400 \begin{array}{l} \div\, 10 = 1440 \text{ gallons.} \\ \div\, 60 = \ \,240 \text{ cubic feet.} \end{array}$$

SERVICE-PIPES AND FITTINGS.

In the term service-pipes are included all pipes branching out of the mains to the consumers' meters, and for the supply of public and private lamps, &c.

Leakage or unaccounted-for gas is due more to defects in service pipes than to all the other causes combined. The leaks are chiefly caused in the pipe by corrosion, or at its junction with the main. Such being the case, it is clear that the utmost care should be devoted to the habilitation and maintenance of this portion of the distributory plant.

Service-pipes are of cast-iron, wrought-iron, and lead. The use of cast-iron pipes for this purpose, is, as a general rule, confined to the supply of gas to large establishments, where the diameter of the pipe exceeds 2 inches. The smaller sizes are too fragile to bear the overhead traffic, and the number of joints is objectionable. Such services as are of less bore than 3 inches are usually of wrought-iron, or lead.

Wrought-iron pipes or tubes are chiefly employed for services. They can be obtained of any convenient length, and are easily and expeditiously fixed.

Wrought-iron tubes and fittings, such as tees, bends, elbows, ferrules, sockets, &c., should be perfectly cylindrical, with no ribs or flat places, and internally as smooth as possible. The welding should be scarcely discernible from the other parts, and the screw should be equally deep throughout the thread.

In laying wrought-iron pipes, the coupling or socket at the end, and which is supplied along with the pipe, should always be removed, the thread painted with red or white lead paint, and then replaced.

Lead pipes have their advantages, though they require more care in laying; and to prevent their sagging in the ground, slabs or laths of wood have to be placed underneath them throughout their length.

On the other hand, they can be laid with fewer joints, the only jointing places being the connections with the main and the meter, unless the premises to be supplied is beyond the ordinary distance from the main. When taken up, also, to be renewed, the old metal is of more value than old iron.

All service-pipes, whether of wrought-iron or lead, when laid in the ground, should be protected from the oxidizing influences of the soil, moisture, and air by being encased in a ⊔-shaped or V-shaped channel of wood or other material, filled, after the pipe has been laid therein, with a mixture of hot pitch and tar. This prolongs their life indefinitely, and prevents leakage, and consequently is well worth the trifling extra cost and trouble entailed.

The tinning or galvanizing of the surface of wrought-iron pipes adds greatly to their durability when laid in sandy soil impregnated with saline matter.

The Barff-Bower process of covering iron with a thin layer of oxide to protect it from corrosion, either in the soil or when exposed to the atmosphere, is peculiarly valuable as applied to wrought-iron tubes and fittings, and deserves to be universally adopted.

Mains should be drilled, not cut with a chisel, for the insertion of service pipes. The full sectional thickness of the metal is thus preserved, and the hole is a true circle in form.

Mr. Upward's drilling apparatus secures immunity from leakage in attaching the service pipe to the main, and it is easily applied and used.

All service-pipes should, if possible, be laid with a slight fall to the —

main to admit of the condensed moisture draining away thereto. When the pipe is of great length, and a continuous inclination to the main is impracticable, a small drip-well, commonly called a bottle-syphon (Fig. 76—on p. 203) should be attached at the lowest point.

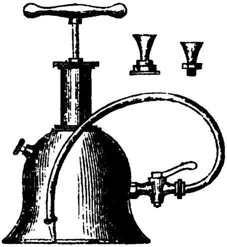

FIG. 75.

The service-cleanser of Messrs. D. Hulett and Co. (Fig. 75) is exceedingly useful for removing water and other obstructions from service pipes.

It is not possible always to see whether a wrought-iron service-pipe is worn out or not, unless it is taken up out of the ground. The under part of the pipe will often be found completely oxidized, when the upper surface is sound and good. The rust forms a shell, which crumbles on being disturbed, but when untouched is sufficient to prevent the immediate escape of gas.

All abrupt angles, such as square elbows, whether in mains, services, or internal fittings, owing to the resistance they offer to the regular and even flow of the gas, act as condensers, and diminish the available pressure. Their use should therefore be discarded wherever practicable, bends or round elbows being much more preferable. For the same reason the internal surface of pipes should be as smooth as possible. No pipe should be put in use without careful examination, and the removal of all existing roughnesses.

2-inch cast-iron pipes as mains,
½-inch wrought-iron pipes as services, and
¼-inch lead or composition pipes for internal supply, should be utterly abandoned.

The first are a grievous source of direct leakage owing to breakages at their junction with the service-pipes; the whole three, if used to any great extent, entail high initial pressure, which is synonymous with a heavy leakage account.

If the distance from the main to the meter does not exceed 30 yards. the following sizes of service-pipes will supply the number of lights named:—

				Wrought-iron tube.
1	to	10	lights (consuming say 4c. ft. per hour each) . .	¾ inch.
11	,,	30	,, ,, ,, ,, . .	1 ,,
31	,,	60	,, ,, ,, ,, . .	1¼ ,,
61	,,	120	,, ,, ,, ,, . .	1½ ,,
121	,,	200	,, ,, ,, ,, . .	2 ,,

The above sizes allow for partial contraction of the area of the *pipe by corrosion or* deposition.

Uniformity in the screws or threads of service-pipes and fittings is reatly to be desired, a large proportion of the leakage being due to the rant of this. The screwed joint may be too slack, in which case ›akage often follows; on the other hand, when a socket is too small to eceive the screwed end of a pipe, instead of running the tap into the ne, or the dies over the other, careless workmen are often content to let he joint pass, provided they succeed in getting a single thread to bite. 'he natural settlement of the ground, the traffic over the surface, or ıe first keen frost, disjoints the connection and an escape follows.

Pitch of the Whitworth Taps and Dies for Gas Tubing.

Internal Diameter of Pipe.	External Diameter of Pipe.	Number of Threads per inch.	Internal Diameter of Pipe.	External Diameter of Pipe.	Number of Threads per inch.
$\frac{1}{8}$	·385	28	2	2·347	11
$\frac{1}{4}$	·520	19	$2\frac{1}{8}$	2·467	11
$\frac{3}{8}$	·665	19	$2\frac{1}{4}$	2·587	11
$\frac{1}{2}$	·822	14	$2\frac{3}{8}$	2·794	11
$\frac{3}{4}$	1·034	14	$2\frac{1}{2}$	3·001	11
1	1·302	11	$2\frac{5}{8}$	3·124	11
$1\frac{1}{8}$	1·492	11	$2\frac{3}{4}$	3·247	11
$1\frac{1}{4}$	1·650	11	$2\frac{7}{8}$	3·367	11
$1\frac{3}{8}$	1·745	11	3	3·485	11
$1\frac{1}{2}$	1·882	11	$3\frac{1}{4}$	3·698	11
$1\frac{5}{8}$	2·021	11	$3\frac{1}{2}$	3·912	11
$1\frac{3}{4}$	2·047	11	$3\frac{3}{4}$	4·125	11
$1\frac{7}{8}$	2·245	11	4	4·339	11

To Calculate the Required Size of Service-Pipes.

The following table gives the theoretical diameter required for ipes which have to supply a certain number of burners at distances ·om the street main. The table is calculated by the formula

$d = \sqrt[5]{\frac{Q^2 s l}{(1350)^2 h}}$, being the same as that used in the determination

f the quantities of gas delivered by large pipes.

As, however, the actual discharge from small pipes is less than the ılculated quantity, the tabular number must be increased by one-ıird if the service-pipe is of lead, and by one-half if of wrought-iron. Then of the latter material, it is not advisable to put in the ground a ipe of less than $\frac{3}{4}$-inch in diameter.

Example *of the Manner of Using the Table.*—Supposing there are) lights to be supplied, at the distance of 70 feet from the main, the ıbular number opposite 70 and under 40 is ·73540. To this add one-ıird if a lead service, making ·98053, and one-half if a wrought-iron ›rvice, making 1·10310. The size of pipe next above the numbers is inch and $1\frac{1}{4}$ inch respectively, and this is the size required.

TABLE

Showing the Diameter of Pipes, in Decimals of an Inch, to Supply Lights at Certain Distances from the Main.

Distance of Lights from Main in Feet.	Number of Lights, each Burning Five Feet per Hour, with a Pressure of One Inch.						
	3.	5.	10.	15.	20.	25.	30.
5	·15457	·18882	·24912	·29424	·32876	·35946	·38824
10	·17682	·21691	·28617	·33660	·37765	·41291	·44415
15	·19176	·23524	·31034	·36504	·40956	·44779	·48167
20	·20311	·24916	·32872	·38666	·43381	·47429	·51019
30	·22027	·27020	·35649	·41932	·47045	·51438	·55329
40	·23331	·28620	·37760	·44415	·49830	.54483	·58605
50	·24396	·29927	·39483	·46441	·52105	·56970	·61280
60	·25302	·31024	·40950	·48167	·54041	·59086	·63556
70	·26094	·32010	·42231	·49675	·55733	·60936	·65546
80	·26802	·32876	·43375	·51255	·57241	·62585	·67011
90	·27439	·33660	·44408	·52235	·58606	·64077	·68925
100	·28023	·34377	.45354	·53348	·59854	·65442	·70393
150	·30391	·37281	.49185	·57054	·64909	·70970	·76339
200	·32191	·39489	·52098	·61281	·68753	·75173	·80860
250	·33660	·41291	·54476	·64077	·71891	·78604	·84550
300	·34901	·42825	·56507	·66457	·74561	·81523	·87691

Distance of Lights from Main in Feet.	Number of Lights, each Burning Five Feet per Hour, with a Pressure of One Inch.					
	40.	50.	100.	150.	200.	300.
5	·43381	·47430	·62577	·73911	·82581	·97525
10	·49832	·54484	·71881	·83775	·94862	1·1157
15	·54041	·59086	·77954	·91693	1·0288	1·2099
20	·57241	·62585	·82571	·97123	1·0897	1·2815
30	·62076	·67872	·89546	1·0533	1·1817	1·3898
40	·65753	·71891	·94848	1·1156	1·2517	1·4721
50	·68753	·75172	·99177	1·1665	1·3089	1·5393
60	·71307	·77928	1·0286	1·2099	1·3574	1·5965
70	·73540	·80405	1·0608	1·2478	1·3999	1·6464
80	·75530	·82582	1·0895	1·2874	1·4378	1·6910
90	·77331	·84550	1·1155	1·3121	1·4721	1·7313
100	·78978	·86351	1·1394	1·3400	1·5035	1·7681
150	·85649	·93688	1·2356	1·4532	1·6305	1·9175
200	·90720	·99191	1.3088	1·5393	1·7270	2·0811
250	·94862	1·0371	1·3685	1·6095	1·8058	2·1288
300	·98389	1.0757	1·4197	1·6693	1·8729	2·2540

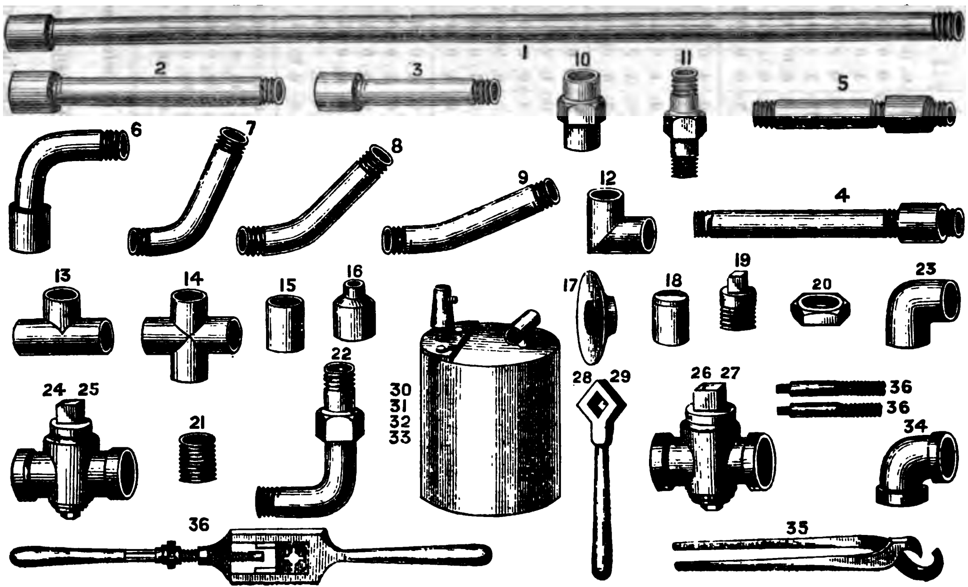
28 29
26 27
24 25

FIG. 76.

PRICE LIST OF WROUGHT-

No.	Internal Diameter. Inches.	⅛		¼		⅜		½		¾		1	
		s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
1	Tubes, 2 to 14 feet long, per foot	0	2	0	2½	0	3	0	4½	0	6	0	8½
2	Pieces, 12 to 23½ inches long, each	0	4	0	5	0	7	0	9	1	0	1	4
3	Do. 3 to 11½ „ „	0	2	0	3	0	4	0	6	0	8	0	11
4	Longscrews, 12 to 23½ „ „	0	5	0	7	0	9	0	11	1	2	1	6
5	Do. 3 to 11½ „ „	0	4	0	5	0	6	0	8	0	10	1	0
6	Bends . . . . „	0	5½	0	6½	0	7	0	8	0	11	1	3
7 8 9	Springs, not Socketed . . „	0	4	0	5	0	6	0	7	0	9	0	11
10 11	Socket Unions (10), Pipe Do. (11)	..		2	0	2	6	3	0	4	0	5	6
12	Elbows, Wrought-Iron . . .	0	6	0	6½	0	7	0	8	0	10	1	2
13	Tees „ . . .	0	6	0	6½	0	7	0	9	1	0	1	3
14	Crosses „ . . .	0	10	1	0	1	0	1	5	1	9	2	3
15	Plain Sockets	0	1½	0	1½	0	2	0	3	0	3½	0	4
16	Diminished Sockets	..		0	3	0	4	0	5	0	6	0	7
17	Flanges	0	8	0	9	0	10	1	0	1	2	1	4
18 19	Caps (18), Plugs (19)	0	2	0	3	0	3	0	4	0	5	0	6
20 21	Backnuts (20), Nipples (21) . .	0	1	0	2	0	2	0	3	0	3½	0	4
22	Union Bends	..		2	6	3	0	3	9	5	0	6	3
23	Round Elbows, Wrought-Iron .	0	7	0	7	0	8	0	9	1	0	1	4
24	Iron Main Cocks	2	3	2	3	2	9	3	6	4	6	6	6
25	Do. with Brass Plugs.	..		..		4	6	5	6	7	6	10	6
26	Round Way Iron Cocks . . .	..		..		3	6	4	0	5	6	7	6
27	Do. with Brass Plugs.	..		..		5	0	6	6	9	0	13	0
28	Cock Spanners, Wrought-Iron .	..		..		1	0	1	4	1	8	2	0
29	Do. Malleable Cast-Iron	..		..		0	7	0	8	0	10	1	2
30	Syphon Boxes, 1 Quart . . .	..		..		..		11	0	12	0	13	0
31	Do. 2 „ . . .	..		..		..		..		16	0	17	0
32	Do. 3 „ . . .	..		..		..		..		20	0	22	0
33	Do. 4 „ . . .	..		..		..		..		21	0	23	0
34	Malleable Cast Round Elbows .	0	6	0	6½	0	7	0	8	0	10	1	2

(35) Tongs or Nippers, (36) Stocks, Dies, and Taps, at prices as quoted by the manufacturer.

If Tubes are required to be of longer length than 14 ft., they are charged at the next higher rate.

Tubes of intermediate diameters charged at the price of the next larger size.

Springs; if socketed, sockets added at list prices.

IRON TUBING AND FITTINGS, &c.

1¼		1½		1¾		2		2¼		2½		2¾		3		3½		4	
s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
0	11	1	2	1	6	1	9	2	7	3	3	4	0	4	6	5	6	7	0
1	8	2	0	2	6	3	0	4	6	6	3	7	6	9	0	11	6	14	6
1	1	1	4	2	0	2	8	4	0	4	9	6	0	7	0	8	0	9	0
2	0	2	6	3	3	4	0	5	6	7	0	8	6	10	0	12	6	15	6
1	8	2	0	2	6	3	0	4	6	5	6	6	6	7	6	8	6	10	0
1	9	2	3	3	3	4	3	6	6	10	0	12	0	16	0	25	0	32	6
1	4	1	8	2	6	3	3	5	6	7	6	10	0	12	0	19	0	26	0
6	9	8	0	9	0	10	0	12	0	14	0	16	0	18	0	22	0	28	0
1	9	2	3	3	0	3	6	5	6	8	6	11	0	14	0	22	0	28	0
1	9	2	6	3	0	3	9	6	0	9	6	12	6	16	6	24	0	30	0
3	0	3	6	4	6	5	3	10	6	16	0	21	0	30	0	42	0	50	0
0	6	0	7	0	9	1	0	1	6	2	6	3	0	3	6	5	0	6	0
0	9	0	11	1	1	1	3	2	0	3	0	4	0	5	0	7	0	9	0
1	6	1	9	2	0	2	6	3	9	5	0	6	9	8	6	10	0	11	6
0	8	0	10	1	0	1	3	2	0	2	6	3	6	4	9	7	0	10	0
0	6	0	8	0	10	1	0	1	9	2	3	3	0	3	6	4	6	5	6
8	6	10	0	11	6	13	6	16	0	19	0	22	0	25	0	30	0	36	0
1	11	2	6	3	4	3	10	6	6	10	0	13	0	16	0	25	0	32	0
8	6	11	0	14	0	18	0	27	0	36	0	44	0	50	0	75	0	90	0
15	0	19	6	25	0	32	0	47	0	60	0	90	0	110	0	140	0	190	0
10	0	13	0	17	6	22	0	38	0	54	0	62	0	70	0	100	0	160	0
19	0	28	0	36	0	42	0	60	0	85	0	105	0	120	0	180	0	280	0
2	4	3	0	3	6	4	0	4	9	6	0	7	6	9	0	12	0	14	0
1	8	2	2	2	9	3	3	4	9	6	0	7	6	9	0	12	0	14	0
14	0	15	0	15	6	16	0	18	0	..		..		..		..		..	
18	0	19	0	21	0	23	0	25	0	30	0	35	0	40	0	..		..	
24	0	25	0	26	6	28	0	32	0	35	0	40	0	45	0	50	0	56	0
25	0	27	0	29	0	31	0	34	0	38	0	42	0	47	0	54	0	60	0
1	9	2	3	3	0	3	6	5	6	9	0	12	0	15	0	30	0	40	0

Discount	Gas tubes and fittings,		per cent.
	Galvanized	do.	do.
	Steam and water	do.	do.
	Galvanized	do.	do.

Iron Cocks over 2 inches at special discounts.

PUBLIC LIGHTING.

The height of a lamp pillar or column, measured from the surface of the ground to the centre of the flame, should not exceed 10 feet.

A ⅜-inch, or even a ½-inch lead pipe is not suitable for placing in the interior of a lamp column. In cold districts the condensed moisture in a pipe of this small bore becomes frozen, filling up the entire length with solid ice in a very short space of time. This is probably due to the wavy irregularities in the pipe preventing the water from draining rapidly away.

Galvanized wrought-iron pipe is best for lamp columns, and for placing against a wall for the supply of a bracket lamp, and ½-inch is the smallest size that should be used. In situations exposed to cutting winds, and where the frost is keen, ¾-inch wrought-iron pipes are best.

If the service pipe at the entrance to the base of a lamp column has not very ample fall to the main, the water of condensation, unable to drain quickly away, will inevitably be frozen at that point during frost, and, by accretion, will eventually interrupt the passage of the gas.

It is not unusual to find one-half the public lights in some districts extinguished at night when a severe frost prevails. This is simply due to mismanagement, as it would not occur if attention were paid to the matters indicated above.

Seventy yards is the maximum distance apart at which public lamps should be placed.

The ordinary four-sided lamp is the most serviceable for general use. It is 14 inches square at the widest part, and made of tinned copper.

The new street lamps designed by Mr. Sugg (Fig. 77) and Mr. Bray (Figs. 78 and 79) with clusters of flat-flame burners, and the lamp and regenerative burner of Herr F. Siemens (Fig. 80) have much improved the lighting of streets and squares wherever they have been introduced; and have proved, at the same time, that efficient street illumination by means of gas is perfectly attainable where there is a willingness on the part of towns' authorities to incur the expense.

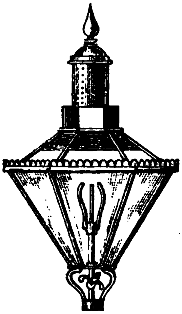

FIG. 77.

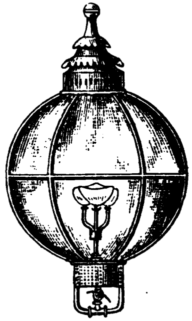

FIG. 78.

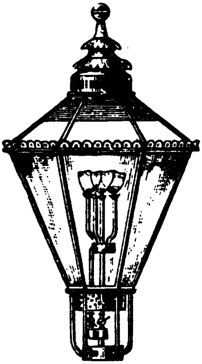

FIG. 79.

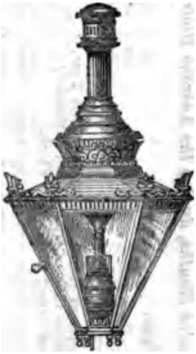

FIG. 80.

The supply of gas to public lamps is usually fixed at 5 cubic feet per our for common gas up to 17 candles value; for cannel gas up to 30 ndles value, the supply per hour varies from 3 to 4 cubic feet.

Satisfactory public lighting, as between gas companies and local thorities, is best secured by the adoption of a good average meter stem, and the application of a regulator to every lamp.

Weight and Thickness of Glass for Public Lamps, &c.

No. of the Glass or Veight in Ounces er Square Foot.	Thickness in Decimals of an Inch.	No. of the Glass or Weight in Ounces per Square Foot.	Thickness in Decimals of an Inch.
12	·059	21	·100
13	·063	24	·111
15	·071	26	·125
16	·077	32	·154
17	·083	36	·167
19	·091	42	·200

Rule to find the Length of Day and Night.

Day.—The hour of sunset, doubled, is the length of the day.
Night.—The hour of sunrise, doubled, is the length of the night.

The Moon's Rising and Setting.

At 4 days old, the Moon sets about 10 o'clock at night.
At 5 ,, ,, ,, ,, 11 ,, ,,
At 6 ,, ,, ,, ,, 12 ,, ,,
At 7 ,, ,, ,, ,, 1 o'clock in the morning.
At 15 ,, ,, the Moon rises ,, 6 ,, in the evening.
At 16 ,, ,, ,, ,, 7¼ ,, ,,
At 17 ,, ,, ,, ,, 8½ ,, ,,
At 18 ,, ,, ,, ,, 10 ,, at night
At 19 ,, ,, ,, ,, 11 ,, ,,
At 20 ,, ,, ,, ,, 12 ,, ,,

TABLE

Showing the Consumption of Gas by One Burner per Month, and for the Twelve Months, during the Average Hours of Burning from Sunset throughout the Year.

Month.	Average Time of Sunset.	Mean Duration of Hours of Burning.	Number of Hours of Night per Month.	Consumption of Gas by One Burner per Month, and for the whole Year. Public Street Lamps assumed to be Lighted from Sunset to Sunrise, and Private Lamps from Sunset until Nine o'Clock.									
				3 Cubic Feet per Hour.		3½ Cubic Feet per Hour.		4 Cubic Feet per Hour.		4½ Cubic Feet per Hour.		5 Cubic Feet per Hour.	
				Public Lamps.	Private Lamps.	Public Lamps.	Private Lamps.	Public Lamps.	Private Lamps.	Public Lamps.	Private Lamps.	Public Lamps.	Private Lamps.
	h. m.	h. m.	h.	c. ft.	c. ft.	c. ft.	c. ft.	c. ft.	c. ft.	c. ft.	c. ft.	c. ft.	c. ft.
January	4 13	16 31	512	1536	445	1792	519	2048	594	2304	668	2560	742
February.	5 7	14 41	411	1233	326	1438	380	1644	436	1850	490	2055	544
March	6 6	12 19	382	1146	270	1337	315	1528	360	1719	405	1910	450
April	6 57	9 50	295	885	185	1032	216	1180	246	1327	277	1475	308
May	7 46	7 48	242	726	115	847	134	968	154	1089	173	1210	191
June	8 16	6 30	195	585	..	683	..	780	..	878	..	975	..
July	8 2	7 0	217	651	..	760	..	868	..	976	..	1085	..
August	7 16	9 54	307	921	162	1074	190	1228	216	1382	242	1535	268
September	6 20	11 30	345	1035	240	1207	280	1380	320	1552	360	1425	400
October	5 21	13 35	421	1263	340	1474	396	1684	453	1895	509	2105	566
November	4 25	15 46	473	1419	413	1655	481	1892	550	2128	619	2665	688
December	3 49	17 0	527	1581	483	1845	564	2108	644	2372	725	2635	803
Total for the Year . .	..	..	4327	12,981	2979	15,144	3475	17,308	3973	19,472	4468	21,635	4960

Showing the Number of Hours during which Gas is usually Burnt in each Month, Quarter, and Year, according to the Times of Lighting and Extinguishing.

Times of Light'ng and Extinguishing.	Lady-Day Quarter.			Midsummer Quarter.			Michaelmas Quarter.			Christmas Quarter.			Lady-Day.	Midsummer.	Michaelmas.	Christmas.	Total of Year.*
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.					
If lighted at dusk and extinguished at—																	
6 p.m.	65	33	4	..	..	..	..	..	2	31	62	80	102	..	2	173	277
7 ,, ...	96	61	31	4	..	..	..	14	22	62	92	111	188	4	36	265	493
8 ,, ...	127	89	62	28	4	..	..	40	52	93	122	142	278	32	92	357	759
9 ,, ...	158	117	93	58	29	8	13	71	82	124	152	173	368	95	166	449	1078
10 ,, ...	189	145	124	88	60	38	44	102	112	155	182	204	458	186	258	541	1443
11 ,, ...	220	173	155	118	91	68	75	133	142	186	212	235	548	277	350	633	1808
12 ,, ...	251	201	186	148	122	98	106	164	172	217	242	266	638	368	442	725	2173
All night . . .	512	411	382	295	242	195	217	307	345	421	473	527	1305	732	869	1421	4327
Lighted at—																	
4 a.m. till daylight	137	98	71	28	2	..	..	16	48	80	110	137	306	30	64	327	727
5 ,, ,,	106	70	40	3	..	..	..	..	18	49	80	106	216	3	18	235	472
6 ,, ,,	75	42	9	..	..	..	..	..	..	18	50	75	126	..	..	143	269
7 ,, ,,	44	14	..	..	..	..	..	..	..	..	20	44	58	..	..	64	122

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* A deduction of one-sixth may be made for moonlight nights; and in the case of private lamps not being lighted on Sundays, deduct one-seventh.

CONSUMERS' GAS METERS.

Gas Meters are either "Wet" or "Dry."

The wet meter has a measuring wheel or drum enclosed in a cast-i case charged with water up to a certain level, called the "water-lin The drum is divided into compartments similar to the station met and the measurement and indication, or registration, of the gas passi through it are performed in the same manner.

The dry meter has usually an outer case of tinned iron. This divided into compartments by a central partition and two or m movable diaphragms with prepared flexible leather sides. The enters and leaves these compartments alternately through val whose passages are made to open and close at the proper mome The alternate expansion and contraction of the inner and outer spa (after the manner of the ordinary bellows), by the pressure of the exerted on the surfaces of the diaphragms, are communicated by lev and cranks to the wheelwork of the indicators which are alike in bo classes of meters.

Meters, as tested under the provisions of the "Sales of Gas A 1859," are stamped as correct by the inspector when their registrati does not vary from the true standard measure of gas more than per cent. in favour of the seller, and 3 per cent. in favour of t consumer. Added together, the range is 5 per cent.

"Compensating" meters were introduced to overcome the difficul caused by the limitation in the range of the water level of wet mete Most of these have a reservoir of water within the case distinct fro the water in which the measuring wheel revolves; and vario automatic expedients are adopted for transferring this water, as long it lasts, to the body of the meter, to compensate for the diminution water therein by evaporation or otherwise.

The action of the Warner and Cowan measuring wheel is independe of the water line, the compensation in this instance being effected a second and smaller wheel contained within, and revolving with, t larger one, but having its partitions arranged in the opposite directio When a depression occurs in the water line of a meter from any cau a volume of gas in excess of the true quantity is passed; but in t case the excess in volume of the gas is returned by the small wheel the meter inlet to be remeasured.

The Sanders and Donovan meter is provided with a compensati hollow float of metal plate, accurately balanced on pivots within t front portion of the case, and independent of the meter's action. the water is added to or withdrawn, the float rises or sinks in prop tion, and thus the correct level is maintained.

When the drum or measuring wheel of a meter is driven at a sp exceeding 120 revolutions per hour (except 2 and 3 lights, when may have a speed of 144), it absorbs an undue amount of the ava able gas pressure, and its registration is falsified. It is importa *therefore, to* see that all meters fixed are adequate to the supply *the greatest* number of lights in use at one time on the premises of t *consumer.*

Mr. Urquhart's "Reliance" meter, and Mr. Hunt's meter, both of which are on the compensating principle, though different in character, are exceptions to the rule above stated, as they measure correctly even when the measuring wheel is caused to revolve at speeds in excess of the normal rate. This result is obtained by a reverse action, by which the gas enters through passages in the valve chamber into the body of the meter, and thence into the drum, from which it makes its escape through the bent tube to the outlet. The inlet pressure thus bears upon nearly the whole surface of the contained water, and the measuring chambers are practically unaltered in capacity.

It need scarcely be pointed out, however, that anything like a general resort to the practice of allowing the use of meters too small for the consumption except at extraordinary pressures, is a serious evil in various ways; loss by leakage is increased, the illuminating power of the gas is practically reduced, and consumers whose meters and fittings are adequate, suffer by the prevailing high pressure.

One-light meters, which formerly were extensively employed, are now altogether inadmissible; and even two-light meters should only be sparingly used. The low price at which gas is sold encourages its extended consumption, and the houses are becoming fewer in number everyday where this small size is sufficient to afford an adequate supply at reasonable pressures, to the quantity of lights in regular use.

The regular periodical inspection of meters is a point of the utmost importance, and ought never to be neglected. The indices of meters in dwelling-houses, &c., should be noted, and water supplied to the proper level wherever deficient at least *once every six weeks*. The mters in mills, manufactories, and large establishments of every kind where the consumption of gas is heavy, should be inspected for the like purpose *once every* 14 *days*.

The inspector should always be provided with a supply of leather washers for the different screws and plugs, to replace any that are worn out.

Meters in cold and exposed positions should be protected by a suitable covering during frost, to prevent interruption to the supply of gas by the water becoming frozen. Woollen rags or wrappings of any kind will answer the purpose.

Testing Meters.

For the verification of gas meters by a public inspector under the Sales of Gas Act, a somewhat elaborate set of apparatus is required.

For ordinary use in testing meters in a gas works, the following may be provided (see Fig. 81):—A standard gasholder of 10 cubic feet capacity. A proving bench. An overhead water cistern. A float of lights, and thermometers for taking the temperature of air and water.

In testing, it is important to secure uniformity in the temperature of the air or gas in the test holder, the water in the tank, and the air in room, viz., 60° Fahr., otherwise corrections for varying temperatures have to be made.

Place the meter to be tested on the proving bench, charge it with water to the proper water line (if a wet meter), and connect it with the holder and to the float of lights (if gas is being used).

See that the pointer of the small metal drum above the index in the wet meter, or of the small circle on the index plate of the dry meter, coincides with one of the figures marked thereon. If it does not, pass a small quantity of gas through till the necessary adjustment is effected.

Next, fill up the test holder till the 0 line of the scale upon it is exactly opposite its pointer.

This being done, turn the gas or air on to the meter, and allow the meter to work till the small metal drum has made one or more revolutions, taking care to close the stop-cock when the pointer of the drum is exactly over the figure from which the start was made.

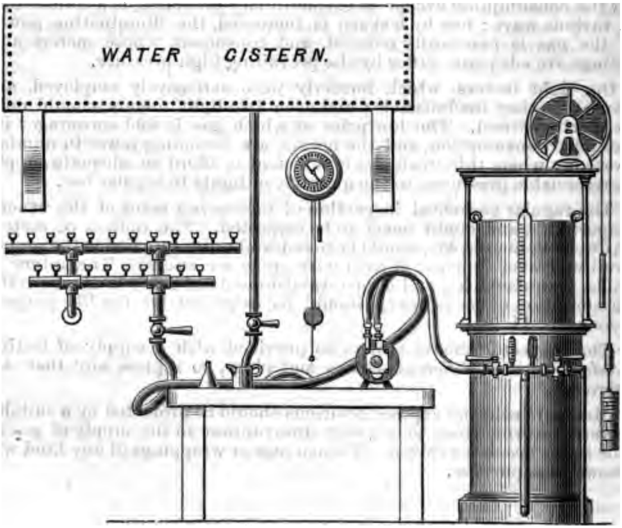

Fig. 81.

The meter registration is then compared with that of the holder scale. If they correspond, the meter is exactly correct; but if the scale on the holder indicates less or more than the small drum on the meter, the percentage of error is calculated; or it can be ascertained on reference to the Table.

The percentage Tables on the following pages are taken from those *issued by the* Metropolitan Board of Works for the use of their Meter *Inspectors.*

TABLES

howing the Percentage of Error in Meters according as their Registration differs from the Indications of the Test Gasholders.

'he sign + is used to indicate *fast*, and — to indicate *slow*.

leters not exceeding 2 per cent. fast, or 3 per cent. slow, are correct within meaning of the "Sales of Gas Act."

Meter Registering 1 Foot.		Meter Registering 2 Feet.		Meter Registering 3 Feet.		Meter Registering 3 Feet.	
ding Scale Gas- lder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder	Amount of Error.
oot.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent
90	+ 11 11	1·80	+ 11·11	·70	+ 11·11	3 16	— 5·06
91	+ 9·89	·81	+ 10·50	71	+ 10·70	·17	— 5·36
92	+ 8·70	·82	+ 9·89	·72	+ 10·30	·18	— 5·66
93	+ 7·25	·83	+ 9 29	·73	+ 9·89	·19	— 5·85
94	+ 6·36	·84	+ 8 70	·74	+ 9·49	3·20	— 6·25
95	+ 5·26	·85	+ 8·11	·75	+ 9·09	·21	— 6·54
96	+ 4·17	·86	+ 7·53	·76	+ 8·70	·22	— 6·82
97	+ 3·09	·87	+ 6·95	·77	+ 8·31	·23	— 7·12
98	+ 2·04	·88	+ 6·38	·78	+ 7·92	·24	— 7·41
99	+ 1·01	·89	+ 5·82	·79	+ 7 53	·25	— 7·70
00	Nil.	1·90	+ 5·26	2·80	+ 7·14	·26	— 7·98
01	— 1·00	91	+ 4·71	·81	+ 6·76	·27	— 8·26
02	— 1·97	·92	+ 4·17	·82	+ 6 38	·28	— 8·54
03	— 2·92	·93	+ 3·63	·83	+ 6·01	·29	— 8·82
04	— 3·85	·94	+ 3·09	·84	+ 5·63	3·30	— 9·09
05	— 4·74	·95	+ 2 56	85	+ 5·26	·31	— 9·36
06	— 5·66	·96	+ 2·04	·86	+ 4·89	·32	— 9·64
07	— 6·54	·97	+ 1·52	·87	+ 4·53	·33	— 9·91
08	— 7·40	·98	+ 1·01	·88	+ 4 17	·34	— 10·18
09	— 8 26	·99	+ 0·50	·89	+ 3·81		
10	— 9·10	2·00	Nil.	2·90	+ 3·45		
11	— 9 91	·01	— 0·50	·91	+ 3 09		
12	— 10·07	·02	— 0·99	·92	+ 2·74		
		·03	— 1·48	·93	+ 2·39		
		04	— 1 96	·94	+ 2·04		
		·05	— 2·44	·95	+ 1·69		
		·06	— 2·91	·96	+ 1·35		
		·07	— 3·38	·97	+ 1·01		
		·08	— 3·85	·98	+ 0·67		
		·09	— 4 31	99	+ 0·33		
		2 10	— 4·76	3·00	Nil.		
		·11	— 5 21	·01	— 0·33		
		·12	— 5·66	·02	— 0·66		
		·13	— 6·10	·03	— 0 99		
		·14	— 6·54	·04	— 1·32		
		·15	— 6·98	·05	— 1·64		
		·16	— 7·41	·06	— 1·96		
		·17	— 7·83	·07	— 2·28		
		18	— 8·26	·08	— 2·60		
		·19	— 8·68	·09	— 2·91		
		2 20	— 9·09	3·10	— 3·22		
		·21	— 9·50	·11	— 3·54		
		·22	— 9 91	·12	— 3·85		
		·23	— 10·31	·13	— 4·16		
		·24	— 10 71	·14	— 4·46		
		·25	— 11·11	15	— 4 76		

Meter Registering 5 Feet.		Meter Registering 5 Feet.		Meter Registering 5 Feet.		Meter Registering 10 Feet.	
Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.
Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.
4·50	+ 11·11	5·03	— 0·60	5·56	— 10·07	9·00	+ 11·11
·51	+ 10·86	·04	— 0·79	·57	— 10·23	·01	+ 10·99
·52	+ 10·62	·05	— 0·99	·58	— 10·39	·02	+ 10·86
·53	+ 10·38	·06	— 1·19	·59	— 10·55	·03	+ 10·74
·54	+ 10·13	·07	— 1·38	5·60	— 10·71	·04	+ 10·62
·55	+ 9·89	·08	— 1·57	·61	— 10·87	·05	+ 10·50
·56	+ 9·65	·09	— 1·77	·62	— 11·03	·06	+ 10·38
·57	+ 9·41	5·10	— 1·96	·63	— 11·19	·07	+ 10·25
·58	+ 9·17	·11	— 2·15			·08	+ 10·13
·59	+ 8·93	·12	— 2·34			·09	+ 10·01
4·60	+ 8·70	·13	— 2·53			9·10	+ 9·89
·61	+ 8·46	·14	— 2·72			·11	+ 9·77
·62	+ 8·23	·15	— 2·91			·12	+ 9·65
·63	+ 7·99	·16	— 3·10			·13	+ 9·53
·64	+ 7·76	·17	— 3·29			·14	+ 9·41
·65	+ 7·53	·18	— 3·47			·15	+ 9·29
·66	+ 7·30	·19	— 3·66			·16	+ 9·17
·67	+ 7·07	5·20	— 3·85			·17	+ 9·05
·68	+ 6·84	·21	— 4·03			·18	+ 8·93
·69	+ 6·61	·22	— 4·21			·19	+ 8·81
4·70	+ 6·38	·23	— 4·40			9·20	+ 8·70
·71	+ 6·16	·24	— 4·58			·21	+ 8·58
·72	+ 5·93	·25	— 4·76			·22	+ 8·46
·73	+ 5·71	·26	— 4·94			·23	+ 8·34
·74	+ 5·49	·27	— 5·12			·24	+ 8·23
·75	+ 5·26	·28	— 5·30			·25	+ 8·11
·76	+ 5·04	·29	— 5·48			·26	+ 7·99
·77	+ 4·82	5·30	— 5·66			·27	+ 7·87
·78	+ 4·60	·31	— 5·84			·28	+ 7·76
·79	+ 4·38	·32	— 6·02			·29	+ 7·64
4·80	+ 4·17	·33	— 6·19			9·30	+ 7·53
·81	+ 3·95	·34	— 6·37			·31	+ 7·41
·82	+ 3·73	·35	— 6·54			·32	+ 7·30
·83	+ 3·52	·36	— 6·72			·33	+ 7·18
·84	+ 3·31	·37	— 6·89			·34	+ 7·07
·85	+ 3·09	·38	— 7·06			·35	+ 6·95
·86	+ 2·88	·39	— 7·24			·36	+ 6·84
·87	+ 2·67	5·40	— 7·41			·37	+ 6·72
·88	+ 2·46	·41	— 7·58			·38	+ 6·61
·89	+ 2·25	·42	— 7·75			·39	+ 6·50
4·90	+ 2·04	·43	— 7·92			9·40	+ 6·38
·91	+ 1·83	·44	— 8·09			·41	+ 6·27
·92	+ 1·63	·45	— 8·26			·42	+ 6·16
·93	+ 1·42	·46	— 8·42			·43	+ 6·04
·94	+ 1·21	·47	— 8·59			·44	+ 5·93
·95	+ 1·01	·48	— 8·76			·45	+ 5·82
·96	+ 0·81	·49	— 8·93			·46	+ 5·71
·97	+ 0·60	5·50	— 9·09			·47	+ 5·60
·98	+ 0·40	·51	— 9·26			·48	+ 5·49
·99	+ 0·20	·52	— 9·42			·49	+ 5·37
5·00	N.	·53	— 9·59			9·50	+ 5·26
·01	— 0·20	·54	— 9·75			·51	+ 5·15
·02	— 0·40	·55	— 9·91			·52	+ 5·04

eter stering Feet.	Meter Registering 10 Feet.		Meter Registering 10 Feet.		Meter. Registering 10 Feet.	
Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error
Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.
+ 4·93	10·06	— 0·60	10·59	— 5·57	11·12	— 10·07
+ 4·82	·07	— 0·70	10·60	— 5·66	·13	— 10·15
+ 4·71	·08	— 0·79	·61	— 5·75	·14	— 10·23
+ 4·60	·09	— 0·89	·62	— 5·84	·15	— 10·31
+ 4·49	10·10	— 0·99	·63	— 5·93	·16	— 10·39
+ 4·38	·11	— 1·09	·64	— 6·02	·17	— 10·47
+ 4·28	·12	— 1·19	·65	— 6·10	·18	— 10·55
+ 4·17	·13	— 1·28	·66	— 6·19	·19	— 10·63
+ 4·06	·14	— 1·38	·67	— 6·28	11·20	— 10·71
+ 3·95	·15	— 1·48	·68	— 6·37	·21	— 10·79
+ 3·84	·16	— 1·57	·69	— 6·45	·22	— 10·87
+ 3·73	·17	— 1·67	10·70	— 6·54	·23	— 10·95
+ 3·63	·18	— 1·77	·71	— 6·63	·24	— 11·03
+ 3·52	·19	— 1·86	·72	— 6·72	·25	— 11·11
+ 3·41	10·20	— 1·96	·73	— 6·80		
+ 3·31	·21	— 2·06	·74	— 6·89		
+ 3·20	·22	— 2·15	·75	— 6·98		
+ 3·09	·23	— 2·25	·76	— 7·06		
+ 2·99	·24	— 2·34	·77	— 7·15		
+ 2·88	·25	— 2·44	·78	— 7·24		
+ 2·77	·26	— 2·53	·79	— 7·32		
+ 2·67	·27	— 2·63	10·80	— 7·41		
+ 2·56	·28	— 2·72	·81	— 7·49		
+ 2·46	·29	— 2·82	·82	— 7·58		
+ 2·35	10·30	— 2·91	·83	— 7·66		
+ 2·25	·31	— 3·01	·84	— 7·75		
+ 2·15	·32	— 3·10	·85	— 7·83		
+ 2·04	·33	— 3·19	·86	— 7·92		
+ 1·94	·34	— 3·29	·87	— 8·00		
+ 1·83	·35	— 3·38	·88	— 8·09		
+ 1·73	·36	— 3·47	·89	— 8·17		
+ 1·63	·37	— 3·57	10·90	— 8·26		
+ 1·52	·38	— 3·66	·91	— 8·34		
+ 1·42	·39	— 3·75	·92	— 8·42		
+ 1·32	10·40	— 3·85	·93	— 8·51		
+ 1·21	·41	— 3·94	·94	— 8·59		
+ 1·11	·42	— 4·03	·95	— 8·68		
+ 1·01	·43	— 4·12	·96	— 8·76		
+ 0·91	·44	— 4·21	·97	— 8·84		
+ 0·81	·45	— 4·31	·98	— 8·93		
+ 0·70	·46	— 4·40	·99	— 9·01		
+ 0·60	·47	— 4·49	11·00	— 9·09		
+ 0·50	·48	— 4·58	·01	— 9·18		
+ 0·40	·49	— 4·67	·02	— 9·26		
+ 0·30	10·50	— 4·76	·03	— 9·34		
+ 0·20	·51	— 4·85	·04	— 9·42		
+ 0·10	·52	— 4·94	·05	— 9·51		
Nil.	·53	— 5·03	·06	— 9·59		
— 0·10	·54	— 5·12	·07	— 9·67		
— 0·20	·55	— 5·21	·08	— 9·75		
— 0·30	·56	— 5·30	·09	— 9·83		
— 0·40	·57	— 5·39	11·10	— 9·91		
— 0·50	·58	— 5·48	·11	— 9·99		

Meter Registering 20 Feet.		Meter Registering 20 Feet.		Meter Registering 20 Feet.		Meter Registering 20 Feet.	
Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.
Feet.	Per Cent.	Feet	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.
18·00	+ 11·11	18·53	+ 7·93	19·06	+ 4·93	19·59	+ 2·09
·01	+ 11·05	·54	+ 7·87	·07	+ 4·87	19·60	+ 2·04
·02	+ 10·99	·55	+ 7·82	·08	+ 4·82	·61	+ 1·99
·03	+ 10·92	·56	+ 7·76	·09	+ 4·76	·62	+ 1·94
·04	+ 10·86	·57	+ 7·70	19·10	+ 4·71	·63	+ 1·88
·05	+ 10·80	·58	+ 7·64	·11	+ 4·65	·64	+ 1·83
·06	+ 10·74	·59	+ 7·59	·12	+ 4·60	·65	+ 1·78
·07	+ 10·68	18·60	+ 7·53	·13	+ 4·54	·66	+ 1·73
·08	+ 10·62	·61	+ 7·47	·14	+ 4·49	·67	+ 1·68
·09	+ 10·56	·62	+ 7·41	·15	+ 4·43	·68	+ 1·63
18·10	+ 10·50	·63	+ 7·36	·16	+ 4·38	·69	+ 1·57
·11	+ 10·44	·64	+ 7·30	·17	+ 4·33	19·70	+ 1·52
·12	+ 10·38	·65	+ 7·24	·18	+ 4·28	·71	+ 1·47
·13	+ 10·31	·66	+ 7·18	·19	+ 4·22	·72	+ 1·42
·14	+ 10·25	·67	+ 7·13	19·20	+ 4·17	·73	+ 1·37
·15	+ 10·19	·68	+ 7·07	·21	+ 4·11	·74	+ 1·32
·16	+ 10·13	·69	+ 7·01	·22	+ 4·06	·75	+ 1·26
·17	+ 10·07	18·70	+ 6·95	·23	+ 4·00	·76	+ 1·21
·18	+ 10·01	·71	+ 6·90	·24	+ 3·95	·77	+ 1·16
·19	+ 9·95	·72	+ 6·84	·25	+ 3·89	·78	+ 1·11
18·20	+ 9·89	·73	+ 6·78	·26	+ 3·84	·79	+ 1·06
·21	+ 9·83	·74	+ 6·72	·27	+ 3·78	19·80	+ 1·01
·22	+ 9·77	·75	+ 6·66	·28	+ 3·73	·81	+ 0·96
·23	+ 9·71	·76	+ 6·61	·29	+ 3·68	·82	+ 0·91
·24	+ 9·65	·77	+ 6·55	19·30	+ 3·63	·83	+ 0·86
·25	+ 9·59	·78	+ 6·50	·31	+ 3·57	·84	+ 0·81
·26	+ 9·53	·79	+ 6·44	·32	+ 3·52	·85	+ 0·75
·27	+ 9·47	18·80	+ 6·38	·33	+ 3·46	·86	+ 0·70
·28	+ 9·41	·81	+ 6·32	·34	+ 3·41	·87	+ 0·65
·29	+ 9·35	·82	+ 6·27	·35	+ 3·36	·88	+ 0·60
18·30	+ 9·29	83	+ 6·21	·36	+ 3·31	·89	+ 0·55
·31	+ 9·23	·84	+ 6·16	·37	+ 3·25	19·90	+ 0·50
·32	+ 9·17	·85	+ 6·10	·38	+ 3·20	·91	+ 0·45
·33	+ 9·11	·86	+ 6·04	·39	+ 3·14	·92	+ 0·40
·34	+ 9·05	·87	+ 5·98	19·40	+ 3·09	·93	+ 0·35
·35	+ 8·99	·88	+ 5·93	·41	+ 3·04	·94	+ 0·30
·36	+ 8·93	·89	+ 5·87	·42	+ 2·99	·95	+ 0·25
·37	+ 8·87	18·90	+ 5·82	·43	+ 2·93	·96	+ 0·20
·38	+ 8·81	·91	+ 5·76	·44	+ 2·88	·97	+ 0·15
·39	+ 8·76	·92	+ 5·71	·45	+ 2·82	·98	+ 0·10
18·40	+ 8·70	·93	+ 5·65	·46	+ 2·77	·99	+ 0·05
·41	+ 8·64	·94	+ 5·60	·47	+ 2·72	20·00	Nil.
·42	+ 8·58	·95	+ 5·54	·48	+ 2·67	·02	— 0·10
·43	+ 8·52	·96	+ 5·49	·49	+ 2·61	·04	— 0·20
·44	+ 8·46	·97	+ 5·43	19·50	+ 2·56	·06	— 0·30
·45	+ 8·40	·98	+ 5·37	·51	+ 2·51	·08	— 0·40
·46	+ 8·34	·99	+ 5·31	·52	+ 2·46	20·10	— 0·50
·47	+ 8·29	19·00	+ 5·26	·53	+ 2·40	·12	— 0·60
·48	+ 8·23	·01	+ 5·20	·54	+ 2·35	·14	— 0·70
·49	+ 8·17	·02	+ 5·15	·55	+ 2·30	·16	— 0·79
18·50	+ 8·11	·03	+ 5·09	·56	+ 2·25	·18	— 0·89
·51	+ 8·05	·04	+ 5·04	·57	+ 2·20	20·20	— 0·99
·52	+ 7·99	·05	+ 4·98	·58	+ 2·15	·22	— 1·09

Meter Registering 20 Feet.		Meter Registering 20 Feet.		Meter Registering 20 Feet.		Meter Registering 30 Feet.	
Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.
Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent
20·24	— 1·19	21·30	— 6·10	22·36	— 10·55	27·00	+ 11·11
·26	— 1·28	·32	— 6·19	·38	— 10·63	·02	+ 11·03
·28	— 1·38	·34	— 6·28	22·40	— 10·71	·04	+ 10·95
20·30	— 1·48	·36	— 6·37	·42	— 10·79	·06	+ 10·86
·32	— 1·57	·38	— 6·46	·44	— 10·87	·08	+ 10·78
·34	— 1·67	21·40	— 6·54	·46	— 10·95	27·10	+ 10·70
·36	— 1·77	·42	— 6·63	·48	— 11·03	·12	+ 10·62
·38	— 1·86	·44	— 6·72	22·50	— 11·11	·14	+ 10·54
20·40	— 1·96	·46	— 6·80			·16	+ 10·46
·42	— 2·06	·48	— 6·89			·18	+ 10·38
·44	— 2·15	21·50	— 6·98			27·20	+ 10·30
·46	— 2·25	·52	— 7·06			·22	+ 10·21
·48	— 2·34	·54	— 7·15			·24	+ 10·13
20·50	— 2·44	·56	— 7·24			·26	+ 10·05
·52	— 2·53	·58	— 7·32			·28	+ 9·97
·54	— 2·63	21·60	— 7·41			27·30	+ 9·89
·56	— 2·73	·62	— 7·49			·32	+ 9·81
·58	— 2·82	·64	— 7·58			·34	+ 9·73
20·60	— 2·91	·66	— 7·66			·36	+ 9·65
·62	— 3·01	·68	— 7·75			·38	+ 9·57
·64	— 3·10	21·70	— 7·83			27·40	+ 9·49
·66	— 3·19	·72	— 7·92			·42	+ 9·41
·68	— 3·29	·74	— 8·00			·44	+ 9·33
20·70	— 3·38	·76	— 8·09			·46	+ 9·25
·72	— 3·47	·78	— 8·17			·48	+ 9·17
·74	— 3·57	21·80	— 8·26			27·50	+ 9·09
·76	— 3·66	·82	— 8·34			·52	+ 9·01
·78	— 3·75	·84	— 8·42			·54	+ 8·93
20·80	— 3·85	·86	— 8·51			·56	+ 8·85
·82	— 3·94	·88	— 8·59			·58	+ 8·78
·84	— 4·03	21·90	— 8·68			27·60	+ 8·70
·86	— 4·12	·92	— 8·76			·62	+ 8·62
·88	— 4·21	·94	— 8·84			·64	+ 8·54
20·90	— 4·31	·96	— 8·93			·66	+ 8·46
·92	— 4·40	·98	— 9·01			·68	+ 8·38
·94	— 4·49	22·00	— 9·09			27·70	+ 8·31
·96	— 4·58	·02	— 9·18			·72	+ 8·23
·98	— 4·67	·04	— 9·26			·74	+ 8·15
21·00	— 4·76	·06	— 9·34			·76	+ 8·07
·02	— 4·85	·08	— 9·42			·78	+ 7·99
·04	— 4·94	22·10	— 9·51			27·80	+ 7·92
·06	— 5·03	·12	— 9·59			·82	+ 7·84
·08	— 5·12	·14	— 9·67			·84	+ 7·76
21·10	— 5·21	·16	— 9·75			·86	+ 7·68
·12	— 5·30	·18	— 9·83			·88	+ 7·61
·14	— 5·39	22·20	— 9·91			27·90	+ 7·53
·16	— 5·48	·22	— 9·99			·92	+ 7·45
·18	— 5·57	·24	— 10·07			·94	+ 7·38
21·20	— 5·66	·26	— 10·15			·96	+ 7·30
·22	— 5·75	·28	— 10·23			·98	+ 7·22
·24	— 5·84	22·30	— 10·31			28·00	+ 7·14
·26	— 5·93	·32	— 10·39			·02	+ 7·07
·28	— 6·02	·34	— 10·47			·04	+ 6·99

Meter Registering 30 Feet.		Meter Registering 30 Feet.		Meter Registering 30 Feet.		Meter Registering 30 Feet.	
Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.
Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.
28·06	+ 6·92	29·12	+ 3·02	30·18	— 0·60	31·24	— 3·97
·06	+ 6·84	·14	+ 2·95	30·20	— 0·66	·26	— 4·03
28·10	+ 6·76	·16	+ 2·88	·22	— 0·73	·28	— 4·09
·12	+ 6·69	·18	+ 2·81	·24	— 0·79	31·30	— 4·16
·14	+ 6·61	29·20	+ 2·74	·26	— 0·86	·32	— 4·22
·16	+ 6·53	·22	+ 2·67	·28	— 0·92	·34	— 4·28
·18	+ 6·46	·24	+ 2·60	30·30	— 0·99	·36	— 4·34
28·20	+ 6·38	·26	+ 2·53	·32	— 1·06	·38	— 4·40
·22	+ 6·31	·28	+ 2·46	·34	— 1·12	31·40	— 4·46
·24	+ 6·23	29·30	+ 2·39	·36	— 1·19	·42	— 4·52
·26	+ 6·16	·32	+ 2·32	·38	— 1·26	·44	— 4·58
·28	+ 6·08	·34	+ 2·25	30·40	— 1·32	·46	— 4·64
28·30	+ 6·01	·36	+ 2·18	·42	— 1·38	·48	— 4·70
·32	+ 5·93	·38	+ 2·11	·44	— 1·44	31·50	— 4·76
·34	+ 5·86	29·40	+ 2·04	·46	— 1·51	·52	— 4·82
·36	+ 5·78	·42	+ 1·97	·48	— 1·57	·54	— 4·88
·38	+ 5·71	·44	+ 1·90	30·50	— 1·64	·56	— 4·94
28·40	+ 5·63	·46	+ 1·83	·52	— 1·71	·58	— 5·00
·42	+ 5·56	·48	+ 1·76	·54	— 1·77	31·60	— 5·06
·44	+ 5·49	29·50	+ 1·69	·56	— 1·83	·62	— 5·12
·46	+ 5·41	·52	+ 1·63	·58	— 1·89	·64	— 5·18
·48	+ 5·34	·54	+ 1·56	30·60	— 1·96	·66	— 5·24
28·50	+ 5·26	·56	+ 1·49	·62	— 2·02	·68	— 5·30
·52	+ 5·19	·58	+ 1·42	·64	— 2·09	31·70	— 5·36
·54	+ 5·11	29·60	+ 1·35	·66	— 2·15	·72	— 5·42
·56	+ 5·04	·62	+ 1·28	·68	— 2·22	·74	— 5·48
·58	+ 4·96	·64	+ 1·21	30·70	— 2·28	·76	— 5·54
28·60	+ 4·89	·66	+ 1·14	·72	— 2·34	·78	— 5·60
·62	+ 4·82	·68	+ 1·08	·74	— 2·40	31·80	— 5·66
·64	+ 4·75	29·70	+ 1·01	·76	— 2·47	·82	— 5·72
·66	+ 4·67	·72	+ 0·94	·78	— 2·53	·84	— 5·78
·66	+ 4·60	·74	+ 0·88	30·80	— 2·60	·86	— 5·84
28·70	+ 4·53	·76	+ 0·81	·82	— 2·66	·88	— 5·90
·72	+ 4·45	·78	+ 0·74	·84	— 2·72	31·90	— 5·96
·74	+ 4·38	29·80	+ 0·67	·86	— 2·78	·92	— 6·02
·76	+ 4·31	·82	+ 0·60	·88	— 2·85	·94	— 6·08
·78	+ 4·24	·84	+ 0·53	30·90	— 2·91	·96	— 6·13
28·80	+ 4·17	·86	+ 0·47	·92	— 2·97	·98	— 6·19
·82	+ 4·10	·88	+ 0·40	·94	— 3·04	32·00	— 6·25
·84	+ 4·02	29·90	+ 0·33	·96	— 3·10	·02	— 6·31
·86	+ 3·95	·92	+ 0·26	·98	— 3·16	·04	— 6·37
·88	+ 3·88	·94	+ 0·20	31·00	— 3·22	·06	— 6·42
28·90	+ 3·81	·96	+ 0·13	·02	— 3·29	·08	— 6·48
·92	+ 3·73	·98	+ 0·07	·04	— 3·35	32·10	— 6·54
·94	+ 3·66	30·00	Nil.	·06	— 3·42	·12	— 6·60
·96	+ 3·59	·02	— 0·07	·08	— 3·48	·14	— 6·66
·98	+ 3·52	·04	— 0·13	31·10	— 3·54	·16	— 6·72
29·00	+ 3·45	06	— 0·20	·12	— 3·60	·18	— 6·77
·02	+ 3·38	·08	— 0·27	·14	— 3·66	32·20	— 6·83
·04	+ 3·31	30·10	— 0·33	·16	— 3·72	·22	— 6·89
·06	+ 3·24	·12	— 0·40	·18	— 3·79	·24	— 6·95
·08	+ 3·16	·14	— 0·47	31·20	— 3·85	·26	— 7·01
29·10	+ 3·09	·16	— 0·53	·22	— 3·91	·28	— 7·07

Meter Registering 30 Feet.		Meter Registering 30 Feet.		Meter Registering 40 Feet.		Meter Registering 40 Feet.	
Reading of Scale of Gasholder	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.
Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.
32·30	— 7·12	33·36	— 10·07	36·00	+ 11·11	37·06	+ 7·93
·32	— 7·18	·38	— 10·12	·02	+ 11·05	·08	+ 7·87
·34	— 7·24	33·40	— 10·18	·04	+ 10·99	37·10	+ 7·82
·36	— 7·30	·42	— 10·23	·06	+ 10·92	·12	+ 7·76
·38	— 7·36	·44	— 10·28	·08	+ 10·86	·14	+ 7·70
32·40	— 7·41	·46	— 10·34	36·10	+ 10·80	·16	+ 7·64
·42	— 7·47	·48	— 10·39	·12	+ 10·74	·18	+ 7·59
·44	— 7·53	33·50	— 10·45	·14	+ 10·68	37·20	+ 7·53
·46	— 7·59	·52	— 10·50	·16	+ 10·62	·22	+ 7·47
·48	— 7·64	·54	— 10·55	·18	+ 10·56	·24	+ 7·41
32·50	— 7·70	·56	— 10·61	36·20	+ 10·50	·26	+ 7·36
·52	— 7·76	·58	— 10·66	·22	+ 10·44	·28	+ 7·30
·54	— 7·82	33·60	— 10·71	·24	+ 10·38	37·30	+ 7·24
·56	— 7·87	·62	— 10·76	·26	+ 10·31	·32	+ 7·18
·58	— 7·93	·64	— 10·82	·28	+ 10·25	·34	+ 7·13
32·60	— 7·98	·66	— 10·87	36·30	+ 10·19	·36	+ 7·07
·62	— 8·04	·68	— 10·93	·32	+ 10·13	·38	+ 7·01
·64	— 8·10	33·70	— 10·98	·34	+ 10·07	37·40	+ 6·95
·66	— 8·15	·72	— 11·03	·36	+ 10·01	·42	+ 6·90
·68	— 8·21	·74	— 11·09	·38	+ 9·95	·44	+ 6·84
32·70	— 8·26	·76	— 11·14	36·40	+ 9·89	·46	+ 6·78
·72	— 8·32	·78	— 11·19	·42	+ 9·83	48	+ 6·72
·74	— 8·37			·44	+ 9·77	37·50	+ 6·66
·76	— 8·43			·46	+ 9·71	·52	+ 6·61
·78	— 8·49			·48	+ 9·65	·54	+ 6·55
32·80	— 8·54			36·50	+ 9·59	·56	+ 6·50
·82	— 8·60			·52	+ 9·53	·58	+ 6·44
·84	— 8·66			·54	+ 9·47	37·60	+ 6·38
·86	— 8·71			·56	+ 9·41	·62	+ 6·32
·88	— 8·77			·58	+ 9·35	·64	+ 6·27
32·90	— 8·82			36·60	+ 9·29	·66	+ 6·21
·92	— 8·87			·62	+ 9·23	·68	+ 6·16
·94	— 8·93			·64	+ 9·17	37·70	+ 6·10
·96	— 8·99			·66	+ 9·11	·72	+ 6·04
·98	— 9·04			68	+ 9·05	·74	+ 5·98
33·00	— 9·09			36·70	+ 8·99	·76	+ 5·93
·02	— 9·15			·72	+ 8·93	·78	+ 5·87
·04	— 9·20			·74	+ 8·87	37·80	+ 5·82
·06	— 9·26			·76	+ 8·81	·82	+ 5·76
·08	— 9·31			·78	+ 8·76	·84	+ 5·71
33·10	— 9·36			36·80	+ 8·70	·86	+ 5·65
·12	— 9·42			·82	+ 8·64	·88	+ 5·60
·14	— 9·47			·84	+ 8·58	37·90	+ 5·54
·16	— 9·53			·86	+ 8·52	·92	+ 5·49
·18	— 9·59			·88	+ 8·46	94	+ 5·43
33·20	— 9·64			36·90	+ 8·40	·96	+ 5·37
·22	— 9·70			·92	+ 8·34	·98	+ 5·31
·24	— 9·75			·94	+ 8·29	38·00	+ 5·26
·26	— 9·81			·96	+ 8·23	·02	+ 5·20
·28	— 9·86			·98	+ 8·17	·04	+ 5·15
33·30	— 9·91			37·00	+ 8·11	·06	+ 5·09
·32	— 9·96			·02	+ 8·05	·08	+ 5·04
·34	— 10·01			·04	+ 7·99	38·10	+ 4·98

Meter Registering 40 Feet.		Meter Registering 40 Feet.		Meter Registering 40 Feet.		Meter Registering 40 Feet.	
Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.
Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.
38·12	+ 4·93	39·18	+ 2·09	40·24	— 0·60	41·30	— 3·15
·14	+ 4·87	39·20	+ 2·04	·26	— 0·65	·32	— 3·19
·16	+ 4·82	·22	+ 1·99	·28	— 0·70	·34	— 3·24
·18	+ 4·76	·24	+ 1·94	40·30	— 0·75	·36	— 3·29
38·20	+ 4·71	·26	+ 1·88	·32	— 0·79	·38	— 3·34
22	+ 4·65	·28	+ 1·83	·34	— 0·84	41·40	— 3·38
·24	+ 4·60	39·30	+ 1·78	·36	— 0·89	·42	— 3·43
·26	+ 4·54	·32	+ 1·73	·38	— 0·94	·44	— 3·47
·28	+ 4·49	·34	+ 1·68	40·40	— 0·99	·46	— 3·52
38·30	+ 4·44	·36	+ 1·63	42	— 1·04	·48	— 3·57
·32	+ 4·38	·38	+ 1·57	·44	— 1·09	41·50	— 3·61
·34	+ 4·33	39·40	+ 1·52	·46	— 1·14	·52	— 3·66
·36	+ 4·28	·42	+ 1·47	·48	— 1·19	·54	— 3·71
·38	+ 4·22	·44	+ 1·42	40·50	— 1·24	·56	— 3·75
38·40	+ 4·17	·46	+ 1·37	·52	— 1·28	·58	— 3·80
·42	+ 4·11	·48	+ 1·32	·54	— 1·33	41·60	— 3·85
·44	+ 4·06	39·50	+ 1·26	·56	— 1·38	·62	— 3·90
·46	+ 4·00	·52	+ 1·21	·58	— 1·43	·64	— 3·94
·48	+ 3·95	·54	+ 1·16	40·60	— 1·48	·66	— 3·99
38·50	+ 3·90	·56	+ 1·11	62	— 1·53	·68	— 4·03
·52	+ 3·84	·58	+ 1·06	·64	— 1·57	41·70	— 4·08
·54	+ 3·78	39·60	+ 1·01	·66	— 1·62	·72	— 4·12
·56	+ 3·73	·62	+ 0·96	·68	— 1·67	·74	— 4·17
·58	+ 3·68	·64	+ 0·91	40·70	— 1·72	·76	— 4·21
38·60	+ 3·63	·66	+ 0·86	·72	— 1·77	78	— 4·26
·62	+ 3·57	·68	+ 0·81	·74	— 1·82	41·80	— 4·31
·64	+ 3·52	39·70	+ 0·75	·76	— 1·86	·82	— 4·36
·66	+ 3·46	·72	+ 0·70	·78	— 1·91	·84	— 4·40
·68	+ 3·41	·74	+ 0·65	40·80	— 1·96	·86	— 4·45
38·70	+ 3·36	·76	+ 0·60	·82	— 2·01	·88	— 4·49
·72	+ 3·31	·78	+ 0·55	·84	— 2·06	41·90	— 4·54
·74	+ 3·25	39·80	+ 0·50	·86	— 2·10	·92	— 4·58
·76	+ 3·20	·82	+ 0·45	·88	— 2·15	·94	— 4·63
·78	+ 3·14	·84	+ 0·40	40·90	— 2·20	·96	— 4·67
38·80	+ 3·09	·86	+ 0·35	·92	— 2·25	·98	— 4·72
·82	+ 3·04	·88	+ 0·30	·94	— 2·30	42·00	— 4·76
·84	+ 2·99	39·90	+ 0·25	·96	— 2·34	·02	— 4·81
·86	+ 2·93	·92	+ 0·20	·98	— 2·39	·04	— 4·85
·88	+ 2·88	·94	+ 0·15	41·00	— 2·44	·06	— 4·90
38·90	+ 2·82	·96	+ 0·10	·02	— 2·49	·08	— 4·94
·92	+ 2·77	·98	+ 0·05	·04	— 2·53	42·10	— 4·99
·94	+ 2·72	40·00	Nil.	·06	— 2·58	·12	— 5·03
96	+ 2·67	·02	— 0·05	·08	— 2·63	·14	— 5·08
·98	+ 2·61	·04	— 0·10	41·10	— 2·68	·16	— 5·12
39·00	+ 2·56	·06	— 0·15	·12	— 2·72	·18	— 5·17
·02	+ 2·51	·08	— 0·20	·14	— 2·78	42·20	— 5·21
·04	+ 2·46	40·10	— 0·25	·16	— 2·82	·22	— 5·26
·06	+ 2·40	.12	— 0·30	·18	— 2·87	·24	— 5·30
·08	+ 2·35	.14	— 0·35	41·20	— 2·91	·26	— 5·35
39·10	+ 2·30	.16	— 0·40	·22	— 2·96	·28	— 5·39
·12	+ 2·25	.18	— 0·45	·24	— 3·01	42·30	— 5·44
·14	+ 2·20	40·20	— 0·50	·26	— 3·06	·32	— 5·48
·16	+ 2·15	22	— 0·55	·28	— 3·10	·34	— 5·53

Meter Registering 40 Feet.		Meter Registering 40 Feet.		Meter Registering 40 Feet.		Meter Registering 50 Feet.	
Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas holder.	Amount of Error	Reading of Scale of Gas-holder.	Amount. of Error.
Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.
42·36	— 5·57	43·42	— 7·88	44·48	— 10·07	45·00	+ 11·11
·38	— 5·62	44	— 7·92	44·50	— 10·11	·02	+ 11·06
42·40	— 5·66	·46	— 7·96	·52	— 10·15	·04	+ 11·01
·42	— 5·71	·48	— 8·00	·54	— 10·19	·06	+ 10·96
·44	— 5·75	43·50	— 8·05	·56	— 10·23	·08	+ 10·91
·46	— 5·80	·52	— 8·09	·58	— 10·27	45·10	+ 10·86
·48	— 5·84	·54	— 8·13	44·60	— 10·31	·12	+ 10·81
42·50	— 5·88	·56	— 8·17	·62	— 10·35	·14	+ 10·76
·52	— 5·93	·58	— 8·22	·64	— 10·39	·16	+ 10·72
·54	— 5·98	43·60	— 8·26	·66	— 10·43	·18	+ 10·67
·56	— 6·02	·62	— 8·30	·68	— 10·47	45·20	+ 10·62
·58	— 6·06	·64	— 8·34	44·70	— 10·51	·22	+ 10·57
42·60	— 6·10	·66	— 8·38	·72	— 10·55	·24	+ 10·52
·62	— 6·15	·68	— 8·42	·74	— 10·59	·26	+ 10·48
·64	— 6·19	43·70	— 8·47	·76	— 10·63	·28	+ 10·43
·66	— 6·24	·72	— 8·51	·78	— 10·67	45·30	+ 10·38
·68	— 6·28	·74	— 8·55	44·80	— 10·71	·32	+ 10·33
42·70	— 6·33	·76	— 8·59	·82	— 10·75	·34	+ 10·28
·72	— 6·37	·78	— 8·64	·84	— 10·79	·36	+ 10·23
·74	— 6·41	43·80	— 8·68	·86	— 10·84	·38	+ 10·18
·76	— 6·45	·82	— 8·72	·88	— 10·87	45·40	+ 10·13
·78	— 6·50	·84	— 8·76	44·90	— 10·91	·42	+ 10·08
42·80	— 6·54	·86	— 8·80	·92	— 10·95	·44	+ 10·03
·82	— 6·59	·88	— 8·84	·94	— 10·99	·46	+ 9·99
·84	— 6·63	43·90	— 8·89	·96	— 11·03	·48	+ 9·94
·86	— 6·68	·92	— 8·93	·98	— 11·07	45·50	+ 9·89
·88	— 6·72	·94	— 8·97	45·00	— 11·11	·52	+ 9·84
42·90	— 6·76	·96	— 9·01			·54	+ 9·79
·92	— 6·80	·98	— 9·05			·56	+ 9·75
·94	— 6·85	44·00	— 9·09			·58	+ 9·70
·96	— 6·89	·02	— 9·14			45·60	+ 9·65
·98	— 6·94	·04	— 9·18			·62	+ 9·60
43·00	— 6·98	·06	— 9·22			·64	+ 9·55
·02	— 7·02	·08	— 9·26			·66	+ 9·50
·04	— 7·06	44·10	— 9·30			·68	+ 9·46
·06	— 7·11	·12	— 9·34			45·70	+ 9·41
·08	— 7·15	·14	— 9·38			·72	+ 9·36
43·10	— 7·20	·16	— 9·42			·74	+ 9·31
·12	— 7·24	·18	— 9·47			·76	+ 9·27
·14	— 7·28	44·20	— 9·51			·78	+ 9·22
·16	— 7·32	·22	— 9·55			45·80	+ 9·17
·18	— 7·37	·24	— 9·59			·82	+ 9·12
43·20	— 7·41	·26	— 9·63			·84	+ 9·07
·22	— 7·45	·28	— 9·67			·86	+ 9·03
·24	— 7·49	44·30	— 9·71			·88	+ 8·98
·26	— 7·54	·32	— 9·75			45·90	+ 8·93
·28	— 7·58	·34	— 9·79			·92	+ 8·88
43·30	— 7·62	·36	— 9·83			·94	+ 8·84
·32	— 7·66	·38	— 9·87			·96	+ 8·79
·34	— 7·71	44·40	— 9·91			·98	+ 8·75
·36	— 7·75	·42	— 9·95			46·00	+ 8·70
·38	— 7·79	·44	— 9·99			·02	+ 8·65
43·40	— 7·83	·46	— 10·03			·04	+ 8·60

Meter Regis ering 50 Feet.		Meter Registering 50 Feet.		Meter Registering 50 Feet.		Meter Registering 50 Feet.	
Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas holder.	Amount of Error.
Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.
46·06	+ 8·56	47·12	+ 6·11	48·18	+ 3·77	49·24	+ 1·55
·08	+ 8·51	·14	+ 6·07	48·20	+ 3·73	·26	+ 1·50
46·10	+ 8·46	·16	+ 6·02	·22	+ 3·69	·28	+ 1·46
·12	+ 8·41	·18	+ 5·98	·24	+ 3·65	49·30	+ 1·42
·14	+ 8·37	47·20	+ 5·93	·26	+ 3·60	·32	+ 1·38
·16	+ 8·32	·22	+ 5·89	·28	+ 3·56	·34	+ 1·34
·18	+ 8·28	·24	+ 5·84	48·30	+ 3·52	·36	+ 1·29
46·20	+ 8·23	·26	+ 5·80	·32	+ 3·48	·38	+ 1·25
·22	+ 8·18	·28	+ 5·75	·34	+ 3·44	49·40	+ 1·21
·24	+ 8·13	47·30	+ 5·71	·36	+ 3·39	·42	+ 1·17
·26	+ 8·09	·32	+ 5·67	·38	+ 3·35	·44	+ 1·13
·28	+ 8·04	·34	+ 5·62	48·40	+ 3·31	·46	+ 1·09
46·30	+ 7·99	·36	+ 5·58	·42	+ 3·27	·48	+ 1·05
·32	+ 7·94	·38	+ 5·53	·44	+ 3·22	49·50	+ 1·01
·34	+ 7·90	47·40	+ 5·49	·46	+ 3·18	·52	+ 0·97
·36	+ 7·85	·42	+ 5·44	·48	+ 3·13	·54	+ 0·93
·38	+ 7·81	·44	+ 5·40	48·50	+ 3·09	·56	+ 0·89
46·40	+ 7·76	·46	+ 5·35	·52	+ 3·05	·58	+ 0·85
·42	+ 7·71	·48	+ 5·31	·54	+ 3·01	49·60	+ 0·81
·44	+ 7·67	47·50	+ 5·26	·56	+ 2·96	·62	+ 0·77
·46	+ 7·62	·52	+ 5·22	·58	+ 2·92	·64	+ 0·73
·48	+ 7·58	·54	+ 5·17	48·60	+ 2·88	·66	+ 0·68
46·50	+ 7·53	·56	+ 5·13	·62	+ 2·84	·68	+ 0·64
·52	+ 7·48	·58	+ 5·08	·64	+ 2·80	49·70	+ 0·60
·54	+ 7·44	47·60	+ 5·04	·66	+ 2·75	·72	+ 0·56
·56	+ 7·39	·62	+ 5·00	·68	+ 2·71	·74	+ 0·52
·58	+ 7·35	·64	+ 4·95	48·70	+ 2·67	·76	+ 0·48
46·60	+ 7·30	·66	+ 4·91	·72	+ 2·63	·78	+ 0·44
·62	+ 7·25	·68	+ 4·86	·74	+ 2·59	49·80	+ 0·40
·64	+ 7·21	47·70	+ 4·82	·76	+ 2·54	·82	+ 0·36
·66	+ 7·16	·72	+ 4·78	·78	+ 2·50	·84	+ 0·32
·68	+ 7·12	·74	+ 4·73	48·80	+ 2·46	·86	+ 0·28
46·70	+ 7·07	·76	+ 4·69	·82	+ 2·42	·88	+ 0·24
·72	+ 7·02	·78	+ 4·64	·84	+ 2·38	49·90	+ 0·20
·74	+ 6·98	47·80	+ 4·60	·86	+ 2·33	·92	+ 0·16
·76	+ 6·93	·82	+ 4·56	·88	+ 2·29	·94	+ 0·12
·78	+ 6·89	·84	+ 4·51	48·90	+ 2·25	·96	+ 0·08
46·80	+ 6·84	·86	+ 4·47	·92	+ 2·21	·98	+ 0·04
·82	+ 6·79	·88	+ 4·42	·94	+ 2·17	50·00	Nil.
·84	+ 6·75	47·90	+ 4·38	·96	+ 2·12	·02	− 0·04
·86	+ 6·70	·92	+ 4·34	·98	+ 2·08	·04	− 0·08
·88	+ 6·66	·94	+ 4·30	49·00	+ 2·04	·06	− 0·12
46·90	+ 6·61	·96	+ 4·25	·02	+ 2·00	·08	− 0·16
·92	+ 6·56	·98	+ 4·21	·04	+ 1·96	50·10	− 0·20
·94	+ 6·52	48·00	+ 4·17	·06	+ 1·91	·12	− 0·24
·96	+ 6·47	·02	+ 4·13	·08	+ 1·87	·14	− 0·28
·98	+ 6·43	·04	+ 4·08	49·10	+ 1·83	·16	− 0·32
47·00	+ 6·38	·06	+ 4·04	·12	+ 1·79	·18	− 0·36
·02	+ 6·34	·08	+ 3·99	·14	+ 1·75	50·20	− 0·40
·04	+ 6·29	48·10	+ 3·95	·16	+ 1·71	·22	− 0·44
·06	+ 6·25	·12	+ 3·91	·18	+ 1·67	·24	− 0·48
·08	+ 6·20	·14	+ 3·86	49·20	+ 1·63	·26	− 0·52
47·10	+ 6·16	·16	+ 3·82	·22	+ 1·59	·28	− 0·56

Meter Registering 50 Feet.		Meter Registering 50 Feet.		Meter Registering 50 Feet.		Meter Registering 50 Feet.	
Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount. of Error.	Reading of Scale of Gasholder.	Amount of Error.	Reading of Scale of Gasholder.	Amount of Error.
Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.
50·30	— 0·60	51·36	— 2·65	53·05	— 5·75	55·70	— 10·23
·32	— 0·64	·38	— 2·69	·10	— 5·84	·75	— 10·31
·34	— 0·68	51·40	— 2·72	·15	— 5·93	·80	— 10·39
·36	— 0·71	·42	— 2·76	·20	— 6·02	·85	— 10·47
·38	— 0·75	·44	— 2·80	·25	— 6·10	·90	— 10·55
50·40	— 0·79	·46	— 2 83	·30	— 6·19	·95	— 10·63
·42	— 0·83	·48	— 2·87	·35	— 6·28	56·00	— 10·71
·44	— 0·87	51·50	— 2·91	·40	— 6·37	·05	— 10·79
·46	— 0·91	·52	— 2·95	·45	— 6·45	·10	— 10·87
·48	— 0·95	·54	— 2·99	53·50	— 6·54	·15	— 10·95
50·50	— 0·99	·56	— 3·02	·55	— 6·63	·20	— 11·03
·52	— 1·03	58	— 3·06	·60	— 6·72	·25	— 11·11
·54	— 1·07	51·60	— 3·10	·65	— 6·80		
·56	— 1·11	·62	— 3·14	·70	— 6·89		
·58	— 1·15	·64	— 3·18	·75	— 6·98		
50·60	— 1 19	·66	— 3·21	·80	— 7·06		
·62	— 1·23	·68	— 3·25	·85	— 7·15		
·64	— 1·27	51·70	— 3·29	·90	— 7·24		
·66	— 1·30	·72	— 3·33	·95	— 7·32		
·68	— 1·34	·74	— 3·36	54·00	— 7·41		
50·70	— 1 38	·76	— 3·40	·05	— 7·49		
·72	— 1·42	·78	— 3·43	·10	— 7·58		
·74	— 1·46	51·80	— 3·47	·15	— 7·66		
·76	— 1·49	·82	— 3·51	·20	— 7·75		
·78	— 1·53	·84	— 3·55	·25	— 7·83		
50·80	— 1·57	·86	— 3·58	·30	— 7·92		
·82	— 1·61	·88	— 3·62	·35	— 8·00		
·84	— 1·65	51·90	— 3·66	·40	— 8·09		
·86	— 1·69	·92	— 3·70	·45	— 8·17		
·88	— 1·73	·94	— 3·74	54·50	— 8·26		
50·90	— 1·77	·96	— 3·77	·55	— 8·34		
·92	— 1·81	·98	— 3·81	·60	— 8·42		
·94	— 1·85	52·00	— 3·85	·65	— 8·51		
·96	— 1·88	·05	— 3·94	·70	— 8·59		
·98	— 1·92	·10	— 4·03	·75	— 8·68		
51·00	— 1·96	·15	— 4·12	·80	— 8·76		
·02	— 2·00	·20	— 4·21	·85	— 8·84		
·04	— 2·04	·25	— 4·31	·90	— 8·93		
·06	— 2·07	·30	— 4·40	·95	— 9·01		
·08	— 2·11	·35	— 4·49	55·00	— 9·09		
51·10	— 2·15	·40	— 4·58	·05	— 9·18		
·12	— 2·19	·45	— 4·67	·10	— 9·26		
·14	— 2·23	52·50	— 4·76	·15	— 9·34		
·16	— 2·26	·55	— 4·85	·20	— 9·42		
·18	— 2·30	·60	— 4·94	·25	— 9·51		
51·20	— 2·34	·65	— 5·03	·30	— 9 59		
·22	— 2·38	·70	— 5·12	·35	— 9·67		
·24	— 2·42	·75	— 5·21	·40	— 9·75		
·26	— 2·45	·80	— 5 30	·45	— 9·83		
·28	— 2·49	·85	— 5·39	55·50	— 9·91		
51·30	— 2·53	·90	— 5·48	·55	— 9·99		
·32	— 2·57	·95	— 5·57	·60	— 10·07		
·34	— 2·61	53·00	— 5·66	·65	— 10·15		

Meter Registering 100 Feet.		Meter Registering 100 Feet.		Meter Registering 100 Feet.		Meter Registering 100 Feet.	
Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.
Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.
90·00	+ 11·11	92·65	+ 7·93	95·30	+ 4·93	97·95	+ 2·09
·05	+ 11·05	·70	+ 7·87	·35	+ 4·87	98·00	+ 2·04
·10	+ 10·99	·75	+ 7·82	·40	+ 4·82	·05	+ 1·99
·15	+ 10·92	·80	+ 7·76	·45	+ 4·76	·10	+ 1·94
·20	+ 10·86	·85	+ 7·70	95·50	+ 4·71	·15	+ 1·88
·25	+ 10·80	·90	+ 7·64	·55	+ 4·65	·20	+ 1·83
·30	+ 10·74	·95	+ 7·59	·60	+ 4·60	·25	+ 1·78
·35	+ 10·68	93·00	+ 7·53	·65	+ 4·54	·30	+ 1·73
·40	+ 10·62	·05	+ 7·47	·70	+ 4·49	·35	+ 1·68
·45	+ 10·56	·10	+ 7·41	·75	+ 4·43	·40	+ 1·63
90·50	+ 10·50	·15	+ 7·36	·80	+ 4·38	·45	+ 1·57
·55	+ 10·44	·20	+ 7·30	·85	+ 4·33	98·50	+ 1·52
·60	+ 10·38	·25	+ 7·24	·90	+ 4·28	·55	+ 1·47
·65	+ 10·31	·30	+ 7·18	·95	+ 4·22	·60	+ 1·42
·70	+ 10·25	·35	+ 7·13	96·00	+ 4·17	·65	+ 1·37
·75	+ 10·19	·40	+ 7·07	·05	+ 4·11	·70	+ 1·32
·80	+ 10·13	·45	+ 7·01	·10	+ 4·06	·75	+ 1·26
·85	+ 10·07	93·50	+ 6·95	·15	+ 4·00	·80	+ 1·21
·90	+ 10·01	·55	+ 6·90	·20	+ 3·95	·85	+ 1·16
·95	+ 9·95	·60	+ 6·84	·25	+ 3·89	·90	+ 1·11
91·00	+ 9·89	·65	+ 6·78	·30	+ 3·84	·95	+ 1·06
05	+ 9·83	·70	+ 6·72	·35	+ 3·78	99·00	+ 1·01
·10	+ 9·77	·75	+ 6·66	·40	+ 3·73	·05	+ 0·96
·15	+ 9·71	·80	+ 6·61	·45	+ 3·68	10	+ 0·91
·20	+ 9·65	·85	+ 6·55	96·50	+ 3·63	·15	+ 0·86
·25	+ 9·59	·90	+ 6·50	·55	+ 3·57	·20	+ 0·81
·30	+ 9·53	·95	+ 6·44	·60	+ 3·52	·25	+ 0·75
·55	+ 9·47	94·00	+ 6·38	·65	+ 3·46	·30	+ 0·70
·40	+ 9·41	·05	+ 6·32	·70	+ 3·41	35	+ 0·65
·45	+ 9·35	·10	+ 6·27	·75	+ 3·36	·40	+ 0·60
91·50	+ 9·29	·15	+ 6·21	·80	+ 3·31	·45	+ 0·55
·55	+ 9·23	·20	+ 6·16	·85	+ 3·25	99·50	+ 0·50
·60	+ 9·17	·25	+ 6·10	·90	+ 3·20	·55	+ 0·45
·65	+ 9·11	·30	+ 6·04	·95	+ 3·14	·60	+ 0·40
·70	+ 9·05	·35	+ 5·98	97·00	+ 3·09	·65	+ 0·35
·75	+ 8·99	·40	+ 5·93	·05	+ 3·04	·70	+ 0·30
·80	+ 8·93	·45	+ 5·87	·10	+ 2·99	·75	+ 0·25
·85	+ 8·87	94·50	+ 5·82	·15	+ 2·93	80	+ 0·20
·90	+ 8·81	·55	+ 5·76	·20	+ 2·88	·85	+ 0·15
·95	+ 8·76	·60	+ 5·71	·25	+ 2·82	·90	+ 0·10
92·00	+ 8·70	·65	+ 5·65	·30	+ 2·77	·95	+ 0·05
·05	+ 8·64	·70	+ 5·60	·35	+ 2·72	100·00	Nil.
·10	+ 8·58	·75	+ 5·54	·40	+ 2·67	·05	— 0·05
·15	+ 8·52	·80	+ 5·49	·45	+ 2·61	·10	— 0·10
·20	+ 8·46	·85	+ 5·43	97·50	+ 2·56	·15	— 0·15
·25	+ 8·40	·90	+ 5·37	·55	+ 2·51	·20	— 0·20
·30	+ 8·34	·95	+ 5·31	·60	+ 2·46	·25	— 0·25
·35	+ 8·29	95·00	+ 5·26	·65	+ 2·40	·30	— 0·30
·40	+ 8·23	·05	+ 5·20	·70	+ 2·35	·35	— 0·35
·45	+ 8·17	·10	+ 5·15	·75	+ 2·30	·40	— 0·40
92·50	+ 8·11	·15	+ 5·09	·80	+ 2·25	·45	— 0·45
·55	+ 8·05	·20	+ 5·04	·85	+ 2·20	100·50	— 0·50
·60	+ 7·99	·25	+ 4·98	·90	+ 2·15	·55	— 0·55

Meter Registering 100 Feet.		Meter Registering 100 Feet.		Meter Registering 100 Feet.		Meter Registering 100 Feet.	
Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.	Reading of Scale of Gas-holder.	Amount of Error.
Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent.	Feet.	Per Cent
,00·60	— 0·60	103·30	— 3·19	106·00	— 5·66	108·70	— 8·00
·65	— 0·65	·35	— 3·24	·05	— 5·71	·75	— 8·05
·70	— 0·70	·40	— 3·29	·10	— 5·75	·80	— 8·09
·75	— 0·75	·45	— 3·34	·15	— 5·80	·85	— 8·13
·80	— 0·79	103·50	— 3·38	·20	— 5·84	·90	— 8·17
·85	— 0·84	·55	— 3·43	·25	— 5·88	·95	— 8·22
·90	— 0·89	·60	— 3·47	·30	— 5·93	109·00	— 8·26
·95	— 0·94	·65	— 3·52	·35	— 5·98	·05	— 8·30
101·00	— 0·99	·70	— 3·57	·40	— 6·02	·10	— 8·34
·05	— 1·04	·75	— 3·61	·45	— 6·06	·15	— 8·38
·10	— 1·09	·80	— 3·66	106·50	— 6·10	·20	— 8·42
·15	— 1·14	·85	— 3·71	·55	— 6·15	·25	— 8·47
·20	— 1·19	·90	— 3 75	·60	— 6·19	·30	— 8·51
·25	— 1·24	·95	— 3·80	·65	— 6·24	·35	— 8·55
·30	— 1·28	104·00	— 3·85	·70	— 6·28	·40	— 8·59
·35	— 1·33	·05	— 3·90	·75	— 6·33	·45	— 8·64
·40	— 1·38	·10	— 3·94	·80	— 6·37	109·50	— 8·68
·45	— 1·43	·15	— 3·99	·85	— 6·41	·55	— 8·72
101·50	— 1·48	·20	— 3·03	·90	— 6·45	·60	— 8·76
·55	— 1·53	·25	— 3·08	·95	— 6·50	·65	— 8·80
·60	— 1·57	·30	— 3·12	107·00	— 6·54	·70	— 8·84
·65	— 1·62	·35	— 3·17	·05	— 6·59	·75	— 8·89
·70	— 1·67	·40	— 3·21	·10	— 6·63	·80	— 8·93
·75	— 1·72	·45	— 3·26	·15	— 6·68	·85	— 8·97
·80	— 1·77	104·50	— 3·31	·20	— 6·72	·90	— 9·01
·85	— 1·82	·55	— 4·36	·25	— 6·76	·95	— 9·05
·90	— 1·87	·60	— 4·40	·30	— 6·80	110·00	— 9·09
·95	— 1·91	·65	— 4·45	·35	— 6·85	·10	— 9·18
102·00	— 1·96	·70	— 4·49	·40	— 6·89	·20	— 9·26
·05	— 2·01	·75	— 4·54	·45	— 6·94	·30	— 9·34
·10	— 2·06	·80	— 4·58	107·50	— 6·98	·40	— 9·42
·15	— 2·10	·85	— 4·63	·55	— 7·02	·50	— 9·51
·20	— 2·15	·90	— 4·67	·60	— 7·06	·60	— 9·59
·25	— 2·20	·95	— 4·72	·65	— 7·11	·70	— 9·67
·30	— 2·25	105·00	— 4·76	·70	— 7·15	·80	— 9·75
·35	— 2·30	·05	— 4·81	·75	— 7·20	·90	— 9·83
·40	— 2·34	·10	— 4·85	·80	— 7·24	111·00	— 9·91
·45	— 2·39	·15	— 4·90	·85	— 7·28	·10	— 9·99
102·50	— 2·44	·20	— 4·94	·90	— 7·32	·20	— 10·07
·55	— 2·49	·25	— 4·99	·95	— 7·37	·30	— 10·15
·60	— 2·53	·30	— 5·03	108·00	— 7·41	·40	— 10·23
·65	— 2·58	·35	— 5·08	·05	— 7·45	·50	— 10·31
·70	— 2·63	·40	— 5·12	·10	— 7·49	·60	— 10·39
·75	— 2·68	·45	— 5·17	·15	— 7·54	·70	— 10·47
·80	— 2·72	105·50	— 5·21	·20	— 7·58	·80	— 10·55
·85	— 2·78	·55	— 5·26	·25	— 7·62	·90	— 10·63
·90	— 2·82	·60	— 5·30	·30	— 7·66	112 00	— 10·71
·95	— 2·87	·65	— 5·35	·35	— 7·71	·10	— 10·79
103·00	— 2·91	·70	— 5·39	·40	— 7·75	·20	— 10·87
·05	— 2·96	·75	— 5·44	·45	— 7·79	·30	— 10·95
·10	— 3·01	·80	— 5·48	108·50	— 7·83	·40	— 11·03
·15	— 3 06	·85	— 5·53	·55	— 7·88	·50	— 11·11
·20	— 3·10	·90	— 5·57	·60	— 7·92		
·25	— 3·15	·95	— 5·62	·65	— 7·96		

NOTE.—Any other quantity may be calculated by the rule of proportion, thus:—

Meter registering	100·00 feet.
Reading of scale of test gasholder . . .	89·95 „
Difference	10·05 „

89·95 : 100 :: 10·05 : 11·17 fast.

And meter registering	100·00 feet.
Reading of scale of test gasholder . . .	112·55 „
Difference	12·55 „

112·55 : 100 :: 12·55 : 11·15 slow.

TABLE

Showing the Dilatation of Gas in Contact with Water and Saturated with Aqueous Vapour, for given Temperatures. (Professor Airey.)

(Used in making Corrections for Temperature in the Testing of Gas Meters.)

Temperature in Fahrenheit's Scale.	Percentage of Dilatation.	Temperature in Fahrenheit's Scale.	Percentage of Dilatation.	Temperature in Fahrenheit's Scale.	Percentage of Dilatation.
31·40	0	54·33	5½	74·30	11
33·54	½	56·24	6	75·94	11½
35·70	1	58·12	6½	77·23	12
37·84	1½	60·02	7	78·81	12½
39·91	2	62·00	7½	80·40	13
42·05	2½	63·77	8	81·94	13½
44·17	3	65·63	8½	83·44	14
46·22	3½	67·43	9	84·88	14½
48·25	4	69·18	9½	86·39	15
50·32	4½	70·90	10	87·83	15½
52·36	5	72·60	10½	89·20	16

NOTE.—The table shows the percentage of increase of the volume of gas above its volume at the temperature of 31·4° Fahr.

INTERNAL FITTINGS.

'he advantages of an ample supply of good and pure gas are fre-ntly neutralized by the defective manner in which premises are ›d internally.

ad gas-fittings are generally the result of cupidity or ignorance. ›y are a common cause of complaint from consumers who are often ly to attribute the inefficient light which they afford to a want of ssure or purity, or a low illuminating power in the gas.

'he following regulations (with such additions and modifications as y be found necessary) may be adopted with advantage by gas autho-es.

Regulations as to Internal Fittings.

. The company's (or local authority's) servants will in all cases lay :he service-pipe, conveying the same through the outer wall of the mises to be supplied with gas.

. The main-cock must be attached to the end of the service-pipe hin the building, and close to the outer wall.

. The gas meter must be placed perfectly level, either on the floor ›n a substantial support, and within 2 ft. 6 in. of the main-cock.

. The piping attached to the meter, whether inlet or outlet, must be smaller in internal diameter than that of the meter unions.

. The following are the sizes of meters, and their measuring capa-', from which the number of lights which they supply can be readily ›ulated:—

Size of Meters.	Size of Inlet and Outlet. Inches.	Measuring Capacity per Revolution. Cubic Feet.	Measuring Capacity per Hour. Cubic Feet.
2-light	½	1/12	12
3 "	⅝	⅛	18
5 "	¾	¼	30
10 "	1	½	60
15 "	1	¾	90
20 "	1¼	1	120
30 "	1⅜	1½	180
50 "	1½	2½	300
60 "	1½	3	360
80 "	1¾	4	480
100 "	2	5	600
150 "	3	7½	900
200 "	3	10	1200
250 "	4	12½	1500
300 "	4	15	1800
400 "	4	20	2400
500 "	5	25	3000
600 "	5	30	3600

'o ascertain the number of lights which any size of meter will sup-, divide the measuring capacity per hour by the quantity of gas hour which each jet is estimated to consume. Example: What nber of lights, consuming 4 cubic feet of gas per hour, will a 20-light ter supply? Then, $\frac{120}{4}$ = 30 lights, answer.

6. The following are the sizes and lengths of iron, lead or composition tubes to be used according to the number of ordinary lights:—

Internal Diameter of Tubing. Inches.	Greatest Length Allowed. Feet.	Greatest No. of Burners Allowed.
$\frac{3}{8}$	20	3
$\frac{1}{2}$	30	6
$\frac{5}{8}$	40	12
$\frac{3}{4}$	50	20
1	70	35
$1\frac{1}{4}$	100	60
$1\frac{1}{2}$	150	100
2	200	200

Tubing of $\frac{1}{4}$ inch bore is not allowed to be used.

7. The tubes or pipes must be laid with proper fall, and in such a manner that they are easily accessible, and protected from liability to damage. Attention is to be given to leaving a space round them at such places as wall crossings, &c., where fracture or crushing of the pipes might be caused by the subsidence of the building. The joinings of the tubes and pipes are to be made in the most solid and substantial manner; and carefully rounded bends (not elbows) are to be used wherever the direction of a pipe is changed.

8. Floor boards covering pipes must be secured with screws, so that they may be easily removed to afford access to the pipes, especially at the points of connection.

9. On the completion of the work of fitting, and before the piping is covered up, notice thereof must be given in writing to the gas manager (the requisite form for that purpose being obtained at the gas office), who will cause an inspection to be made of the work, and if found in accordance with the regulations herein contained, it will be passed by the company (or local authority), and the gas turned on.

10. If the regulations are not conformed to in every respect, the company (or local authority) reserve the right to refuse a supply of gas until the necessary alterations are made.

11. Gas-fitters complying with these regulations have their names registered on the company's (or local authority's) list of approved fitters, and they are at liberty to designate themselves "Authorized gas-fitters." Repeated negligence will cause the licence to be withdrawn.

Ordinary sitting rooms are best lighted by means of a central chandelier. When the room is of large dimensions, wall brackets may be added. A bracket at each side of the mantelpiece has a tasteful appearance, and lights are handy in that position.

The jets of chandeliers and brackets should be not less than 36 inches from the ceiling.

A tea-spoonful of salad oil added on the top of the water in the tube of a water-slide pendant, tends, in a great measure, to prevent or retard evaporation of the water.

Burners arranged in the horizontal position are not usually effective, and are not to be recommended except on the conditions noted hereafter. The flames of such have an unpleasant pulsatory or tremulous motion, very disagreeable when fixed on a level with or but slightly above the eye of the spectator, due to the upward current of air striking the underside.

The arrangement is bad for another reason—viz., the flame is prevented from receiving its due supply of oxygen on all sides, and as a consequence, the combustion is imperfect; bad illumination, and a deposit of unconsumed carbon on the ceiling being the result.

It is not, however, to be assumed that lights placed in the horizontal or the inclined position are never effective. They can be rendered so, by causing the tails of the flames to impinge one upon the other, and by making provision in the construction of the pendant for the air current to play upon the upper surface of the flame.

The question of the efficient ventilation of rooms where gas is being consumed is one of importance both to the gas producer and the user. The subject has been a comparatively neglected one, although it promises in the future to occupy greater prominence.

Ventilating globe and other lights of various designs have been introduced by Messrs. Sugg, Cowan, Bray, Strode, and other makers, with highly satisfactory results, and their more general adoption is only a question of time. Fig. 82 shows Mr. Cowan's ventilating globe light, and Fig. 83, the ventilating sun-light as made by Mr. Strode.

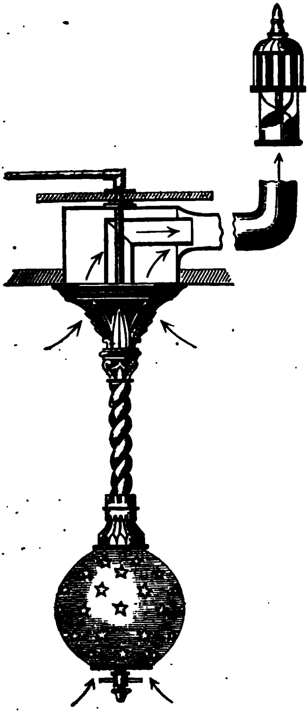

FIG. 82.

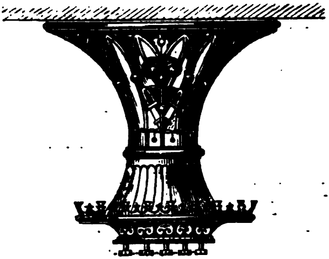

FIG. 83.

To obtain the maximum of light from a burner it is necessary that the pressure, when that it in excess in the mains, as it must necessarily be, should be controlled and regulated in the passage of the gas to the point of ignition.

This cannot be accomplished satisfactorily by checking either the taps on the fittings, or the stop cock at the meter, because there is a continual variation of pressure according to the consumption that is in progress.

The house governor or regulator was invented to achieve that end. It may be fixed on the pipe leading from the meter outlet, or, what is better, on the principal pipe supplying each floor level of the premises.

The regulator is automatic in its action, and when weighted to afford the required pressure for all the burners in use, it will continue to give a practically uniform supply however much the pressure in the mains may vary, or whether the whole or only a portion of the burners being supplied through it may be alight at one time. The "Needle" governor burner of Mr. Peebles and the "Acme" regulating burner of Mr. Wright, are examples of regulation applied close to the point of consumption.

It is a clearly established fact that the lower the pressure (provided there is just sufficient) at which gas can be burned, the better the light. If, instead of being advantageously consumed, the gas is forced through the burners into the atmosphere, the carbon is rapidly oxidized by the excess of air drawn into the flame by the heavy pressure, with the usual unsatisfactory results as regards illumination.

Dr. Letheby found that a vulcanized india-rubber tube of about 30 feet in length, reduced the power of a weak gas to the extent of nearly 25per cent., by absorbing the illuminating hydrocarbons.

Varnish to Prevent the Escape of Gas through India-rubber Tubing.

1½ parts treacle.
2 ,, gum arabic.
7 ,, white wine.
3½ ,, strong alcohol.

First dissolve the treacle and gum in the white wine, and afterwards add the alcohol very slowly, constantly stirring the mixture to prevent the gum from being thrown down.

HANDY RULE

For Estimating (Approximately) the Number of Burners required to Light Churches, Public Halls, and other Large Buildings.

Rule.—The floor area in feet divided by 50 for common gas, and by 70 for cannel gas, will give the number of flat-flame burners required for effective lighting.

Example.—A room is 80 feet long and 56 feet wide. What number of burners is required? Then—

$80 \times 56 = 4480$ sq. ft. area $\frac{4480}{50} =$ say 90 burners with common gas consuming 5 c. ft. per hour each.

$\frac{4480}{70} =$ *say 60 burners* with cannel gas, consuming 4 c. ft. per hour each.

TABLE,

Showing the Loss of Light per cent. through Shades or Globes.
(Mr. W. King.)

	Loss of Light per cent.
Clear glass	10·57
Ground glass (entire surface ground)	29·48
Smooth opal	52·83
Ground opal	55·85
Ground opal, ornamented with painted figures, the figures intervening between the burner and the photometer screen	73·98

TABLE,

Showing the Amount of Light Obstructed by the Use of Globes or Moons. (Mr. A. H. Wood.)

Light	obstructed by	a clear glass globe	about	12	per cent.
,,	,,	a clear globe with slightly ground flowers	,,	24	,,
,,	,,	globes of about the usual pattern	,,	35	,,
,,	,,	globes ground all over	,,	40	,,
,,	,,	opal globes	,,	60	,,
,,	,,	painted opal globes	,,	64	,,
,,	,,	common window glass	,,	9	,,

TABLE,

Showing the Loss of Light through flat Sheets of Glass of different Qualities and Colours. (Mr. F. H. Storer, U.S. America.)

Description of Glass.	Thickness of Glass.		Loss of Light Per Cent.
Thick English plate	$\frac{1}{3}$ of an inch	. . . . . .	6·15
Crystal plate	$\frac{1}{8}$,,	. . . . . .	8·61
English crown	$\frac{1}{8}$,,	. . . . . .	13·08
Double English window glass .	$\frac{1}{8}$,,	. . . . . .	9·39
Double German* ,, . . .	$\frac{1}{8}$,,	. . . . . .	13·00
Single German ,, . . .	$\frac{1}{16}$,,	. . . . . .	4·27
Double German, ground . . .	$\frac{1}{8}$,,	. . . . . .	62·34
Single German ,, ...	$\frac{1}{16}$,,	. . . . . .	65·75
Berkshire (Mass.) ,, ...	$\frac{1}{16}$,,	. . . . . .	62·74
Berkshire enamelled — *i.e.*, ground only upon portions of its surface—small figure .	$\frac{1}{16}$ of an inch	. . . . . .	51·23
Orange coloured window glass.	$\frac{1}{16}$,,	As used for church windows, &c.	34·48
Purple ,, ...	$\frac{1}{8}$,,		85·11
Ruby ,, ...	$\frac{1}{16}$,,		89·62
Green ,, ...	$\frac{1}{16}$,,		81·97
A porcelain transparency . .	$\frac{}{16}$,,	. . . . . .	97·68

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* Among the Boston dealers, the term "German" is applied to glass of Belgian manufacture.

The results of the experiments with globes given in the foregoing tables were obtained with the light in a direct line with the photometer disc, and with the defective moons or globes formerly in use, having narrow openings at the bottom. With the improved globes of the present day, the bottom openings of which are 4 to 5 inches diameter, the results more recently obtained by Mr. F. W. Hartley differ from those detailed.

In 1880, Mr. Hartley carried out a series of experiments with ground and plain glass of various kinds, both flat and rounded on their surface, and with the lighting horizontal and overhead.* These experiments are interesting and valuable, but the details are too lengthy to be given, even in outline, here. The general conclusion, however, at which Mr. Hartley arrived is as follows:—

HORIZONTAL LIGHTING.

Sheet Glass.

1. That ordinary sheet glass, apart from thickness, varies in its obstructive power to the passage of light. That the *percentage loss increases* with the distance of the glass from the flame, and *increases* also as the *light grows* stronger.
2. That ground sheet glass, apart from thickness, also varies in obstructive power. That the *percentage loss increases* with the distance of the glass from the flame, and *decreases* as the *light grows stronger*. That the percentage loss depends on which side, clear or ground is presented to the flame.
3. That with flashed opal the losses follow the same law as ground glass for distance from and for power of light.
4. That with clear glass as an *obstructor* of light in front of the flame and clear glass behind as a *reflector* of light, the reflected light reduces the *loss* to a degree dependent on the distance of each glass from the flame.

Globes.

5. That a clear glass globe obstructs light from an *Argand* flame, but increases the sensible light from a *flat* flame.
6. That globes of ground glass obstruct less light than sheets of ground glass. That the percentage loss *diminishes* as the light grows *stronger;* and is, for an average light, from 18 to 20 per cent.
7. That opal globes obstruct an amount of light equal to 33 to 65 per cent.

OVERHEAD LIGHTING.

8. *That the amount of light yielded by a flame in an angular direction is much less than it yields in a horizontal direction.*
9. That glass globes with elevated or overhead Argand flames *reduce* the power of the light—clear globes, about 3 per cent.; ground globes, about 21 per cent.; and albatrine globes, about 23 per cent.
10. That glass globes with flat-flame burners, at a certain elevation and within a certain radius, *increase* the power of the light—

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* *"Observations on Glass as an Obstructor and Reflector of Artificial Light," by F. W. Hartley*, A. Inst. C.E., *Journal of Gas Lighting*, January, 1881.

clear globes, about 6 per cent.; ground globes, about 9 per cent.; albatrine globes, about 23 per cent.; and German opal globes, about 21 per cent.

11. That reflectors greatly increase the power of the light, within a radius dependent on the shape and size of the reflector; the range in the experiments being from 52 to 92 per cent.
12. That screens at the base of an Argand flame cause a reduction in the power of the light, whatever be the size and form of the reflector.

LEAD AND COMPOSITION PIPES FOR GAS.

Weights per Yard and Lengths usually Manufactured.

Light.			Heavy.		
Diameter Inside.	Weight per Yard. lbs. oz.	Lengths of Bundles usually Manufactured.	Diameter Inside.	Weight per Yard. lbs. oz.	Lengths of Bundles usually Manufactured.
¼ inch.	0 11½	80 yards.	¼ inch.	0 15	67 yards.
⅜ ,,	1 2	60 ,,	⅜ ,,	1 6½	46 ,,
½ ,,	2 0	32 ,,	½ ,,	2 10	26 ,,
⅝ ,,	2 4	25 ,,	⅝ ,,	3 0	20 ,,
¾ ,,	3 3	23 ,,	¾ ,,	3 12	19 ,,
1 ,,	4 8	26 ,,	1 ,,	6 0	20 ,,
1¼ ,,	8 0	16 ,,	1¼ ,,	10 0	12 ,,
1½ ,,	12 0	10 ,,	1½ ,,	14 0	9 ,,
2 ,,	18 0	5 ,,	2 ,,	21 0	5 ,,

BRASS TUBE, PLAIN—WEIGHT PER FOOT.

Diameter. Inches.	Weight. lb.	oz.	Diameter. Inches.	Weight. lbs.	oz.
1-4th	·08 or	1·28	7-8ths	·50 or	8·00
5-16ths	·15	2·40	1 inch	·59	9·44
3-8ths	·19	3·04	1¼ ,,	·81	12·96
7-16ths	·21	3·36	1½ ,,	1·00	16·00
1 half	·25	4·00	1¾ ,,	1·12	17·92
9-16ths	·31	4·96	2 ,,	1·25	20·00
5-8ths	·37	5·92	2½ ,,	1·50	24·00
3-4ths	·43	6·88	3 ,,	1·87	29·92

The size of brass and copper tube is measured by the outside diameter.

BRASS TUBE, SPIRAL AND FLUTED—WEIGHT PER FOOT.

Diameter. Inches.	Spiral, Weight. oz.	Fluted, Weight. oz.	Diameter. Inches.	Spiral, Weight. oz.	Fluted, Weight. oz.
3-8ths	3	2¾	3-4ths	6	6
7-16ths	3½	3¼	7-8ths	7½	7
1 half	3¾	3½	1 inch	9	8
9-16ths	4½	4	1¼ ,,	12	11
5-8ths	5	5	1½ ,,	15	14

SOLDERS.

Fine Solder is an alloy of 2 parts of block tin and 1 of lead (melts at 360° Fahr.). This is used for fine work, such as soldering the drums of meters, for pewter, &c.

Glazing Solder.—Equal parts of block tin and lead. Used for lead.

Plumbing Solder.—1 part block tin, 2 lead. For all kinds of plumbers' joints, and for tin and zinc.

Solder for Copper.—Hard: 3 parts brass, 1 zinc. Soft: 8 brass, 1 zinc.

Brazing Solder or Spelter.—Hard: 1 part copper, 1 zinc. Soft: 4 parts copper, 3 zinc, 1 block tin. For fine brass work: 1 part silver, 8 copper, 8 zinc.

Solder for Steel.—19 parts silver, 3 copper, 1 zinc.

Pewterers' Soft Solder.—2 parts bismuth, 4 lead, 3 tin. Common: 1 part bismuth, 1 lead, 2 tin.

FLUXES FOR SOLDERING.

Iron and steel	Borax or sal ammoniac.
Tinned iron	Resin or chloride of zinc.
Copper and brass	Sal ammoniac or chloride of zinc.
Lead and composition pipes .	Resin and sweet oil.
Zinc	Chloride of zinc.

FOR TINNING BRASS OR IRON.

½ oz. muriatic acid.
¼ oz. mercury.
½ oz. ground block tin.

Mix together, and dilute the whole with a small quantity of cold water. Apply with the finger or a cork.

BRAZING.

The edges of the articles, either iron or brass, to be brazed are scraped thoroughly clean, covered with the brazing solder or spelter in the form of borings or turnings sprinkled over with powdered borax, and exposed to the heat of a clear fire till the solder flows. A smokeless coke or gas fire is best for the purpose. In brazing iron, a covering of loam is sometimes placed over the solder, to exclude the air, till it melts.

BRONZE.

1 quart common vinegar.
2 ozs. sal ammoniac.
1 oz. blue stone (sulphate of copper).

The sal ammoniac and blue stone are well pounded, and then allowed to dissolve in the vinegar. The solution, when ready, is laid on with a common brush, black-leaded whilst damp, and then polished. Lacquer is then applied as described hereafter.

Green Bronze.

To imitate the antique.
1 quart common vinegar.
2 ozs. verdigris.
1 oz. sal ammoniac.

Boil for for a quarter of an hour, filter through paper, and dilute with water. Immerse the article to be bronzed until it acquires the green tinge desired; then wash carefully, and dry in sawdust.

Bronze Powders.

These can be purchased from any dealer in artists' material. They are prepared as follows:—

Copper Bronze Powder.

Strips of copper are dissolved in nitric acid in a glass vessel, and then strips of iron are added, when the dissolved copper is precipitated in the form of a very fine powder. This powder is washed with water and dried, and is then ready for use.

Gold Bronze Powders or Aurum Mosaicum,

Is the basis of many bronze powders. Any desired colour can be produced by mixing it with the common dry pigments. Thus, a red bronze powder is obtained by grinding red lead with it; and a green by the use of verdigris. It is prepared in the following manner:—

> One pound of tin is melted in a crucible, and then poured cautiously into an iron dish containing half a pound of mercury. When cold it is reduced to powder, mixed with seven ounces of flowers of sulphur, and eight ounces of sal ammoniac, and triturated in a mortar. The mixture is then calcined in a flask, which expels the sulphur, mercury, and ammonia, and leaves a residuum in the form and colour of a bright flaky gold powder.

Size for Bronze Powders.

The size is made by boiling four ounces of gum animi to every pound of pure linseed oil in a flask, until the mixture is of the consistency of cream; after which it is diluted with turpentine as required.

The article to be bronzed is coated, by means of a soft brush, with this size; and when nearly dry a piece of soft leather is wrapped round the finger, dipped into the powder, and rubbed gently over it; or it may be laid on with a camel's-hair pencil and then left to dry thoroughly; after which all the loose powder is brushed off.

The bronze may also be mixed with a strong solution of isinglass, and applied in the moist state, like varnish, with a brush. This latter mode, however, is not suitable for articles exposed to the weather.

For Silvering Metals.

Nitrate of silver	10	parts.
Common salt	10	,,
Cream of tartar	30	,,

Moisten with water when ready to apply, and lay the mixture on with a soft brush.

LACQUER AND VARNISH.

The solution of spirits of wine and shellac, known as "simple pale" lacquer, is the basis of most other lacquers. The two ingredients in their proper proportions, as stated below, are put into a jar or bottle, and allowed to remain for forty-eight hours, being briskly shaken three or four times during the interval. At the expiration of the time named, the most of the shellac will be dissolved. The mixture is then carefully strained through filtering paper, to free it from grit and other foreign substances, and to remove any particles of undissolved shellac that may remain.

Different tints or shades, producing red, green, yellow, &c., are obtained by mixing with the pale lacquer various colouring ingredients, such as dragon's blood, arnotto, gamboge, turmeric, saffron, &c. The proper way of adding these is to stir them in a cup with a small quantity of the pale lacquer, afterwards straining the whole through a piece of thin cloth or gauze, and filtering if necessary.

The article to be lacquered is heated slightly by means of a steam kettle or stove; or it may be held over a hot iron plate till just as hot as to allow of its being touched by the finger without burning. The heat must not be greater than this. The lacquer is then applied with a soft camel's-hair brush.

Simple Pale Lacquer.

1 pint of spirits of wine.
4 ozs. of shellac.

Fine Pale Lacquer.

1 pint of spirits of wine.
1 oz. of pure white shellac.
1 dr. of gamboge.
2 drs. of Cape aloes.

Fine Pale Lacquer, for Silvered or Tinned Work.

1 pint of spirits of wine.
1 oz. of pure white shellac.

Gold Lacquer.

1 pint of spirits of wine.
3 ozs. of shellac.
½ oz. of turmeric.
2 drs. of arnotto.
2 drs. of saffron.

Deep Gold Lacquer.

1 pint of spirits of wine.
3 ozs. of shellac.
½ oz. of turmeric.
4 drs. of dragon's blood.

Red Lacquer.

1 pint of spirits of wine.
4 ozs. of shellac.
4 drs. dragon's blood.
1 dr. of gamboge.

Yellow Lacquer.

1 pint of spirits of wine.
2 ozs. of shellac.
2 drs. of gamboge.
4 drs. of Cape aloes.

Green Lacquer for Bronze.

1 pint of spirits of wine.
4 ozs. of shellac.
4 drs. of tumeric.
½ dr. of gamboge.

Iron Lacquer.

1 quart of turpentine.
¾ lb. of asphalte.
2 ozs. of shellac.

To Clean Old Brass Work for Lacquering.

a strong lye of wood ashes, and strengthen with soap lees; put brass work, and the old lacquer will come off. Next, dip it in a n of nitric acid and water, strong enough to remove the dirt; t immediately in clean water; dry well, and lacquer.

Varnish for Iron Work.

a quantity of gas tar for four or five hours, till it runs as thin as add one quart of turpentine to a gallon of the tar, and boil r half hour. Apply the varnish whilst hot.

Golden Varnish.

erize 1 drachm of saffron and ½ a drachm of dragon's blood, and em into 1 pint of spirits of wine. Add 2 ounces of gum shellac lrachms of Soccotrine aloes. Dissolve the whole by gentle heat. painted work, varnished with this mixture, will appear almost o gold.

Varnish for Outdoor Wood Work.

together one gallon of gas tar and 2½ lbs. of white copperas. whilst hot.

Glue Cement to Resist Moisture.

1 part glue.
1 part black resin.
¼ part red ochre.

with the least possible quantity of water.

PUBLIC ILLUMINATIONS.

In provincial towns the Gas Manager is usually called upon arrange and superintend the illuminations that take place to celebr any great national or local event. On such occasions the follow particulars will be found useful:—

Mode of Supply and Price of Gas.

Illumination devices are generally supplied with gas direct from main, without the intervention of a meter to register the consumpti Where the Illuminations are anything like universal, the fixing meters is altogether impracticable.

Taking the consumption of each jet* to be at the rate of one cu foot of gas per hour, which is a fair average, including loss by leakage a trial lighting, the following will be the rate of charge according to price per 1000 cubic feet:—

At 6s.	6d.	per 1000,	·078	of a penny	per jet*	per hour.
6	5	,,	077	,,	,,	,,
6	4	,,	·076	,,	,,	,,
6	3	,,	·075	,,	,,	,,
6	2	,,	·074	,,	,,	,,
6	1	,,	·073	,,	,,	,,
6	0	,,	·072	,,	,,	,,
5	11	,,	·071	,,	,,	,,
5	10	,,	·070	,,	,,	,,
5	9	,,	·069	,,	,,	,,
5	8	,,	·068	,,	,,	,,
5	7	,,	·067	,,	,,	,,
5	6	,,	·066	,,	,,	,,
5	5	,,	·065	,,	,,	,,
5	4	,,	·064	,,	,,	,,
5	3	,,	·063	,,	,,	,,
5	2	,,	·062	,,	,,	,,
5	1	,,	·061	,,	,,	,,
5	0	,,	·060	,,	,,	,,
4	11	,,	·059	,,	,,	,,
4	10	,,	·058	,,	,,	,,
4	9	,,	·057	,,	,,	,,
4	8	,,	·056	,,	,,	,,
4	7	,,	·055	,,	,,	,,
4	6	,,	·054	,,	,,	,,
4	5	,,	·053	,,	,,	,,
4	4	,,	·052	,,	,,	,,
4	3	,,	·051	,,	,,	,,
4	2	,,	·050	,,	,,	,,
4	1	,,	·049	,,	,,	,,
4	0	,,	·048	,,	,,	,,
3	11	,,	·047	,,	,,	,,
3	10	,,	·046	,,	,,	,,
3	9	,,	·045	,,	,,	,,
3	8	,,	·044	,,	,,	,,
3	7	,,	·043	,,	,,	,,

---

* *By the term* "*jet*," as here used, is meant the small gas flame at each ho *drilled or punched* in the pipes forming the different devices.

At 3s.	6d.	per 1000,	·042	of a penny	per jet	per hour.
3	5	,,	·041	,,	,,	,,
3	4	,,	·040	,,	,,	,,
3	3	,,	·039	,,	,,	,,
3	2	,,	·038	,,	,,	,,
3	1	,,	·037	,,	,,	,,
3	0	,,	·036	,,	,,	,,
2	11	,,	·035	,,	,,	,,
2	10	,,	·034	,,	,,	,,
2	9	,,	·033	,,	,,	,,
2	8	,,	·032	,,	,,	,,

Vhen the ordinary No. 1, 2, and 3 fishtail burners are employed, the ısumption may be reckoned at the rate of 3, 4, and 5 cubic feet per ır each respectively, and charged accordingly.

t is proper to stipulate that no Illumination should amount to less ın 25s. or 30s.

Service or Supply Pipes.

t is a common rule for the gas company to convey at their own cost ervice-pipe from the main, and from 8 to 12 feet up the front of the lding to be illuminated, provided the whole length of pipe required s not exceed 36 feet. A charge is made for any additional length. e expense of fixing the devices in their position is also charged. To end of the pipe in front of the building a stop-cock is attached for ıtting off or regulating the supply of gas.

'are should be taken to have the pipes of ample capacity, otherwise Illumination will be poor and ineffective.

Vhen the building to be illuminated is large, it is advisable to run a service-pipe at each end, and one in the centre, connecting them ether in front; each pipe, of course, having a distinct connexion h the main in the street.

'he service-pipes are temporary only, being lent by the gas company, l are removed by them when the Illuminations are over.

Devices.

'he devices are paid for by the private inhabitants or the local horities, or by both, as the case may be.

'hey may consist of—

tial letters, single-lined—thus, A—and double-lined—thus, .

Mottoes—straight, curved, or circular.
Lanterns with coloured devices,
Laurel Scrolls.
Garlands. Festoons.
True-lovers' Knots.
Masonic Emblems.
Eight-pointed Stars.
Brunswick Stars.
Crescents. Crosses.
Plumes. Aureoles.
Crowns. Shields.
Heraldic Crests.
Corporation Arms.

} Figs. 84 to 99; on pages 240, 241.

ıer devices suitable to the particular occasion.

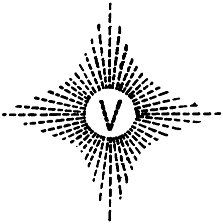


FIG. 84.

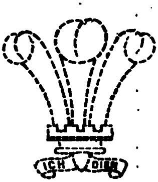


FIG. 85.

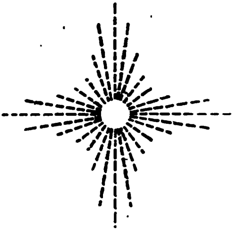


FIG. 86.

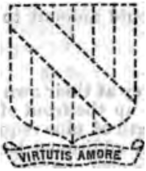


FIG. 87.

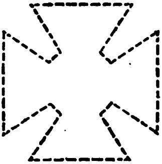


FIG. 88.

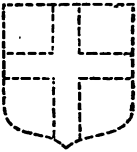


FIG. 89.

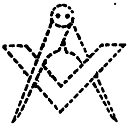


FIG. 90.

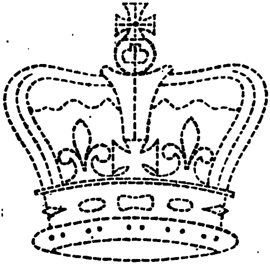


FIG. 91.

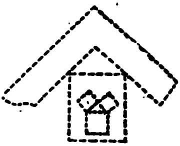


FIG. 92.

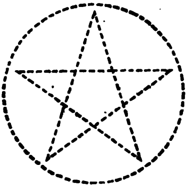


FIG. 93.

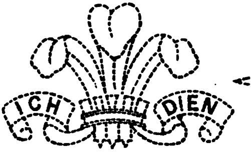


FIG. 94.

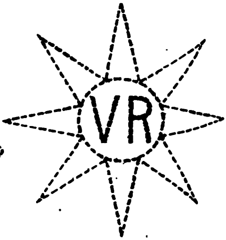


FIG. 95.

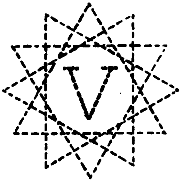


FIG. 96.

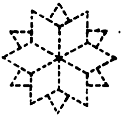


FIG. 97.

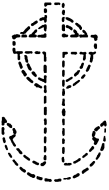


FIG. 98.

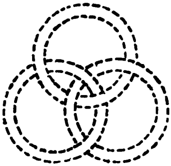


FIG. 99.

'he devices are made by the manufacturers of gas-fittings, wrought- n tubing, and others, and are supplied to gas authorities and the de at about the following prices, net :—

gle-lined Letters, in Iron or Copper, fitted with Strong Union Couplings.

Length of Letter.	Size of Inlet.	Price.
18 inches	⅜ths inch bore	11s. 0d. each.
24 ,, ...	⅜ ,, ...	12 6 ,,
30 ,, ...	⅜ ,, ...	13 6 ,,
36 ,, ...	⅜ ,, ...	15 0 ,,
42 ,, ...	½ ,, ...	18 0 ,,
48 ,, ...	½ ,, ...	21 0 ,,
54 ,, ...	¾ ,, ...	25 0 ,,
60 ,, ...	¾ ,, ...	30 0 ,,

)ouble-lined Letters, in Iron or Copper, fitted with Strong Union Couplings.

ngth of Letter.	Size of Inlet.	Price.
18 inches	⅜ths inch bore	12s. 6d. each.
24 ,, ...	⅜ ,, ...	15 0 ,,
30 ,, ...	½ ,, ...	17 6 ,,
36 ,, ...	½ ,, ...	20 0 ,,
42 ,, ...	¾ ,, ...	24 0 ,,
48 ,, ...	¾ ,, ...	28 0 ,,
54 ,, ...	1 ,, ...	33 0 ,,
60 ,, ...	1 ,, ...	40 0 ,,

Brunswick Stars and Stars with Eight Points, made of Wrought-Iron Welded Pipe, and fitted with Strong Union Couplings.

Diameter.	Size of Inlet.	Price with Star Centre.			Price with Shield Centre.			Price with Plume Centre.		
		£	s.	d.	£	s.	d.	£	s.	d.
3 feet	1 inch bore	2	0	0	2	2	0	2	17	0
4 ,,	1¼ ,,	2	12	0	2	15	0	3	10	0
5 ,,	1¼ ,,	3	6	6	3	10	0	4	5	0
6 ,,	1¼ ,,	4	15	0	5	0	0	5	15	0
7 ,,	1½ ,,	6	3	6	6	10	0	7	5	0
8 ,,	2 ,,	7	7	0	7	15	0	8	10	0

Crowns and Plumes cost about one-third more than Stars.

Scrolls, Garlands, Heraldic Crests, and other devices, at prices varying according to the elaboration of the design.

Wrought-iron pipes, drilled, and with Star jets inserted, are supplied at about the ordinary list price.

The devices may be "home-made," and if so will be less expensive; but unless constructed by skilled and tasteful workmen, they will present a scraggy, irregular appearance when lighted up.

Illuminated Borders.

A very pretty effect, easily managed, and one that gives a rich fulness to the central Illumination of a building, is obtained by running wrought-iron tubing along the principal angles, with holes drilled in the tube at distances of about 6 inches apart, and having small jets or star burners inserted. The burners may be placed wider apart, and globes made use of. These prevent the lights from being extinguished by the wind, and also heighten the general effect. In this case a short piece of brass tube, with elbow socket and gallery, must be inserted. Globes ground all over, or white opal globes, show to the best advantage.

COLOURED FIRES.

A display of Coloured Fires, at intervals, from prominent points of elevation, adds greatly to the effect of an Illumination.

The following are some excellent recipes for their production:—

Lilac Fire.

		Oz.	Drms.
Chlorate of potash	49 parts, or	7	13
Sulphur	25 ,,	4	0
Chalk	20 ,,	3	3
Black oxide of copper	6 ,,	1	0

This composition weighs 1 lb., and costs 2s. 3d.

Purple Fire.

		Oz.	Drms.
Chlorate of potash	43 parts, or	6	14
Nitrate of potash (saltpetre)	22½ ,,	3	10
Sulphur	22½ ,,	3	10
Black oxide of copper	10 ,,	1	9
Black sulphide of mercury (Ethiop's mineral)	2 ,,	0	5

Weight, 1 lb.; cost, 2s. 3d.

Blue or Bengal Fire.

		Oz.	Drms.
Dry nitrate of potash	6 parts, or	10	10½
Sulphur	2 „	3	9½
Tersulphide of antimony	1 „	1	12

Weight, 1 lb.; cost, 1s., or,

		Oz.	Drms.
Ammonic sulphate of copper	8 parts, or	8	8
Chlorate of potash	6 „	6	7
Shellac	1 „	1	1

Weight, 1 lb.; cost, 3s. 3d.

Green Fire.

		Oz.	Drms.
Nitrate of baryta	77 parts, or	12	5
Sulphur	13 „	2	1
Chlorate of potash	5 „	0	13
Charcoal or lamp black	3 „	0	8
Metallic arsenic	2 „	0	5

Weight, 1 lb.; cost, 1s. 6d., or

		Oz.	Drms.
Nitrate of baryta	9 parts, or	10	10
Shellac	3 „	3	9
Chlorate of potash	1½ „	1	13

Weight, 1 lb.; cost, 1s. 6d.

Yellow Fire.

		Oz.	Drms.
Nitrate of soda	75 parts, or	12	0
Sulphur	19 „	3	1
Charcoal or lamp black	6 „	0	15

Weight, 1 lb.; cost, 1s. 6d.

Crimson Fire.

		Oz.	Drms.
Nitrate of strontia	80 parts, or	10	0
Sulphur	22½ „	2	14
Chlorate of potash	20 „	2	8
Charcoal or lamp black	5 „	0	10

Weight, 1 lb.; cost, 1s. 6d.

Red Fire.

		Oz.	Drms.
Nitrate of strontia	40 parts, or	10	0
Sulphur	13 „	3	2
Chlorate of potash	5 „	1	9
Charcoal or lamp black	3 „	0	11
Sulphide of antimony	4 „	1	0

Weight, 1 lb.; cost, 1s. 6d., or

		Oz.	Drms.
Nitrate of strontia	9 parts, or	10	10
Shellac	3 „	3	9
Chlorate of potash	1½ „	1	13

Weight, 1 lb.; cost, 1s. 6d.

White Indian Fire.

		Oz.	Drms.
Nitrate of potash	24 parts, or	11	10
Sulphur	7 „	3	6
Sulphide of arsenic (Realgar)	2 „	1	0

Weight, 1 lb.; cost, 1s.

In no case should the chlorate of potash be ground along with the sulphur, as ignition, caused by the friction might ensue.

The ingredients should be reduced to the finest powder (excepting the shellac, which should only be beaten into small fragments) by bruising them in a mortar made of hard wood, the chlorate of potash being ground separately. They should then be intimately mixed together, by passing them three or four times through a hair sieve. When mixed, keep the material in a close stoppered bottle, to prevent spontaneous combustion. All the ingredients must be perfectly dry to ensure success.

The mixtures are best fired in hemispherical dishes or ladles, made of beaten-iron, about 5 inches diameter and 2½ inches deep in the centre. The fumes arising from the different fires should be avoided.

A pound in weight of any of the mixtures is sufficient for a fire (though any quantity may be used), and the cost varies from 1s. to 2s. 3d. each. The ingredients can be obtained from almost any chemist and druggist.

ILLUMINATING POWER.

For testing the illuminating power of gas in accordance with the statutory provisions, the Bunsen photometer is used, and the Letheby-Bunsen form of the apparatus, Fig. 100, is that generally adopted.

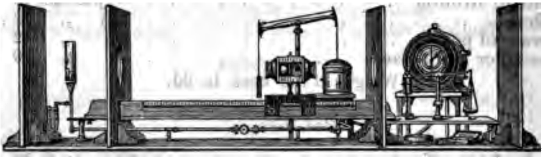


FIG. 100.

The standard candle is a sperm candle, six of which weigh 1 lb., and each burns 120 grains of sperm per hour.

The gas is supplied through an experimental meter, and burns at one end of a graduated bar, and the candle at the other; a movable disc of prepared paper being placed between the two.

This disc, which is contained within a sliding box or carriage, fitted *with two reflectors*, is moved between the two lights until its opposite *sides are equally* illuminated, whereupon the illuminating power of the gas is read off by the operator on inspection of the figures on the graduated bar.

The bar is graduated in accordance with the law that lights which equally illuminate an object are to each other as the square of their distance from such object. Thus, assuming that the distance from the disc to the gas flame is 80 inches, and to the candle flame 20 inches, then $80^2 = 6400$, and $20^2 = 400$, or as 16 to 1, the illuminating value of the gas as compared with the candle.

The following apparatus are also required, viz.:—A governor to regulate the gas pressure; a clock striking every minute; a King's pressure-gauge; a candle balance and weights; a thermometer and a barometer.

The apparatus is arranged and fixed on a substantially made table, placed in the photometer room. This room may be conveniently made about 10 or 12 feet square, and should be ventilated; but currents of air which would affect the steadiness of the gas and candle flames must be guarded against. Provision is made to exclude the daylight, and the walls are coloured a dull black.

Statutory Regulations for Testing the Illuminating Power of Gas.

The provisions in Schedule A of the Gas-Works Clauses Act, 1871, in regard to the apparatus for, and the mode of testing the illuminating power of gas, are as follows:—

Regulations in respect of Testing Apparatus.—The apparatus for testing the illuminating power of the gas shall consist of the improved form of Bunsen's photometer, known as Letheby's open 60-inch photometer, or Evans's enclosed 100-inch photometer, together with a proper meter, minute clock, governor, pressure gauge, and balance.

The burner to be used for testing the gas shall be such as shall be prescribed.

The candles used for testing the gas shall be sperm candles of six to the pound, and two candles shall be used together.

Mode of Testing for Illuminating Power.—The gas in the photometer is to be lighted at least fifteen minutes before the testings begin, and it is to be kept continuously burning from the beginning to the end of the tests.

Each testing shall include ten observations of the photometer, made at intervals of a minute.

The consumption of the gas is to be carefully adjusted to 5 cubic feet per hour.

The candles are to be lighted at least ten minutes before beginning each testing, so as to arrive at their normal rate of burning, which is shown when the wick is slightly bent and the tip glowing. The standard rate of consumption for the candles shall be 120 grains each per hour. Before and after making each set of ten observations of the photometer, the Gas Examiner shall weigh the candles; and if the combustion shall have been more or less per candle than 120 grains per hour, he shall make and record the calculations requisite to neutralize the effects of this difference.

The average of each set of ten observations is to be taken as representing the illuminating power of that testing.

Instructions of the London Gas Referees as to the Times and Mode of Testing for Illuminating Power.

The testings for illuminating power shall be three in number daily.

The photometers to be used in the testing places shall be the improved forms of the Bunsen photometer, prescribed and certified by the Referees.

The burner attached to the photometer shall be a standard burner corresponding to that which has been deposited with the Warden of the Standards in accordance with Section 37 of the Gaslight and Coke Company's Act, 1876. A description of the standard burners to be used for testing common gas and cannel gas respectively is given. (See page 248.)

The gas in the photometer is to be kept burning for at least fifteen minutes before any testing is made.

The disc used in the photometer shall be of the kind known as the Bunsen disc, and shall be changed at least once a week. The chimneys are to be cleaned daily.

The candles shall be such as are described in Section 25 of the Metropolis Gas Act of 1860; namely, sperm candles of six to the pound, each burning 120 grains an hour. Two of these candles shall be used together.

Each testing shall consist of ten observations of the photometer, made at intervals of one minute.

The rate of burning of the gas in each burner shall be 5 cubic feet per hour,—a rate of consumption which is shown by the long hand of the meter making exactly one revolution per minute for several minutes consecutively.

The candles are to be lighted at least ten minutes before the beginning of each testing, so as to have attained their normal rate of burning. Before and after making each testing the Gas Examiner shall weigh the candles; and if the rate of consumption per candle shall not have exceeded 126 grains per hour, or fallen short of 114 grains per hour, he shall make, and record in a book to be kept for the purpose, the calculations requisite to neutralize the effects of this difference.

If the rate of consumption shall have varied from the prescribed rate beyond the above-named limits, the testing is to be rejected and a fresh testing made.

The Gas Examiner, shall, at least once a week, compare the meter-clock with the standard-clock in each testing place.

At the time of each testing the Gas Examiner shall observe and record the temperature of the gas, as shown by the thermometers attached to the meters, and also the height of the barometer. The volumes of the gas operated upon during the testings may be corrected from these data (the standard of comparison being, for the barometer, 30 inches; and for the thermometer, 60 degrees) by means of the Table. (See pages 250 and 251.) Suppose, for example, the thermometer stands at 54 degrees, and the barometer at 30·3 inches: multiply the quantity of *gas consumed* by the corresponding *tabular number*—the product will *be the corrected* volume of the gas—*i.e.*, the volume the gas would have occupied when measured over water at the standard temperature and pressure. Thus:—

Volume of gas consumed . . . . 5 cubic feet.
Tabular number for barometer and thermometer 1·025.

Then 1·025 × 5 = 5·125, the corrected volume.

Instead of thus correcting the volume of gas consumed, the same object may be attained by dividing the observed illuminating power by the tabular number, or in the manner described on page 120.

The Gas Examiner shall record his observations and calculations for determining illuminating power in the form prescribed on page 249.

The calculations for working out the corrections, &c. for the illuminating power of the gas proceed in the following manner:—Add the observations together and divide the sum by 10 to get the average; then, as two candles are used, multiply by 2, to get the illuminating power of the gas if tried against one candle. Then, as the standard rate of consumption of the candles (viz., 120 grains) is to the average number of grains consumed by each per hour, so is the above-obtained number to the actual illuminating power. Finally, make the correction for temperature and pressure, by dividing the illuminating power by the tabular number. For example (taking the tabular number as 1·025):—

Observations—

1st minute—7·8 Consumption of the 2 candles in
2nd " 7·8 10 minutes,
3rd " 8·1 = 41 grains.
4th " 8·2 3
5th " 8·3 ——
6th " 8·5 123 = consumption of 1
7th " 8·6 candle per hour.
8th " 8·4
9th " 8·3
10th " 8·6

10) 82·6

Average, by 2 candles = 8·26
2

Average, by 1 candle = 16·52
Consumption by one candle per hour . } 123 grains.

4956
3304
1652

Standard consumption . 120) 203196
Correction for temp. & pres. 1025) 16933 (16·5 = corrected illum. power in candles.
1025

6683
6150

5330

The foregoing calculation can be shortened as follows, which is the form prescribed on next page.

Average, by 2 candles (arrived at as shown on page 247) . . . . = 8·26
Consumption by 2 candles in 10 minutes 41 grains.

826
3304

20) 33866

Tabular number . . ·1025) 16933 (16·5 = corrected illum. power in candles.
1025

6683
6150

5330

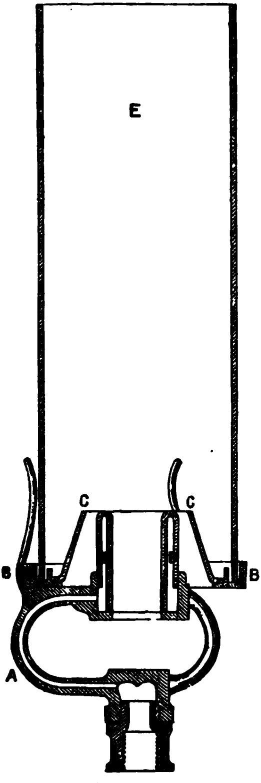


FIG. 101.

The Standard Burner.

The burner which has been adopted as the standard burner for testing common gas was designed by Mr. W. Sugg, and was called by him "Sugg's London Argand, No. 1."

A full-sized section (here given half-size) is appended, in which A represents a supply-pipe, B the gallery, C the cone, D the steatite chamber, E the chimney.

The following are the dimensions of those parts of the burner upon which its action depends:—

	Inch.
Diameter of supply-pipes . . .	0·08
External diameter of annular steatite chamber.	0·84
Internal diameter of annular steatite chamber.	0·48
Number of holes	24
Diameter of each hole	0·045
Internal diameter of cone:—	
At the bottom	1·5
At the top	1·08
Height of upper surface of cone and of steatite chamber above floor of gallery.	0·75
Height of glass chimney. . . .	6
Internal diameter of chimney. .	1⅞

The standard burner for testing cannel gas is a steatite batswing burner, consisting of a cylindrical stem, the top of which is divided by a slit of uniform width.

	Inch.
External diameter of top of stem	0·31
Internal diameter of stem . . .	0·17
Width of slit	0·02
Depth of slit	0·15

Statement of Testings for Illuminating Power.

Date——————18

meter —— Thermometer —— Tabular Number ——

our.	——	——	——
	Consumption of sperm by two candles in ten min. } ——	Consumption of sperm by two candles in ten min. } ——	Consumption of sperm by two candles in ten min. } ——
	Observations.	*Observations.*	*Observations.*
	1st min. ——	1st min. ——	1st min. ——
vations en at vals of ninute.	2nd „ ——	2nd „ ——	2nd „ ——
	3rd „ ——	3rd „ ——	3rd „ ——
	4th „ ——	4th „ ——	4th „ ——
	5th „ ——	5th „ ——	5th „ ——
	6th „ ——	6th „ ——	6th „ ——
	7th „ ——	7th „ ——	7th „ ——
	8th „ ——	8th „ ——	8th „ ——
	9th „ ——	9th „ ——	9th „ ——
	10th „ ——	10th „ ——	10th „ ——
nultiply umber ied by imber of is con- by the candles ninutes, divide y 2.	——	——	——
vide by mber of ites in 40 grs. ere amed.	2) ——	2) ——	2) ——

m. Power at .	——	——	Tabular number ——)———(—— = *Corrected* Average Illum. Power for the day.
, „ .	——	——	
, „ .	——	——	

ride the average inating Power by tabular number ponding to Mean nperature and ure: the quotient be the corrected inating Power for the day.) ——

verage Illum. Power, uncorrected . . . } = —— Candles.

——————

Gas Examiner.

TABLE *to facilitate the Correction of the Volume of Gas at*

BAR.	THER. 40°	42°	44°	46°	48°	50°	52°	54°	56°	58°	60°
28·0	·979	·974	·970	·965	·960	·956	·951	·946	·942	·937	·932
28·1	·983	·978	·973	·969	·964	·959	·955	·951	·945	·941	·936
28·2	·986	·981	·977	·972	·967	·963	·958	·953	·949	·944	·939
28·3	·990	·985	·980	·976	·971	·966	·961	·957	·952	·947	·942
28·4	·993	·988	·984	·979	·974	·970	·965	·960	·955	·951	·946
28·5	·997	·992	·987	·983	·978	·973	·968	·964	·959	·954	·949
28·6	1·001	·995	·991	·986	·981	·977	·972	·967	·962	·958	·953
28·7	1·004	·999	·994	·990	·985	·980	·975	·970	·966	·961	·956
28·8	1·007	1·003	·998	·993	·988	·984	·979	·974	·969	·964	·959
28·9	1·011	1·006	1·001	·997	·992	·987	·982	·977	·973	·968	·963
29·0	1·014	1·010	1·005	1·000	·995	·990	·986	·981	·976	·971	·966
29·1	1·018	1·013	1·008	1·004	·939	·994	·980	·984	·979	·975	·969
29·2	1·021	1·017	1·012	1·007	1·002	·997	·992	·988	·982	·978	·973
29·3	1·025	1·020	1·015	1·011	1·006	1·001	·996	·991	·986	·981	·976
29·4	1·028	1·024	1·019	1·014	1·009	1·004	·999	·995	·990	·985	·980
29·5	1·032	1·027	1·022	1·018	1·013	1·008	1·003	·998	·993	·988	·983
29·6	1·036	1·031	1·026	1·021	1·016	1·011	1·006	1·001	·996	·992	·986
29·7	1·039	1·034	1·029	1·025	1·019	1·015	1·010	1·005	1·000	·995	·990
29·8	1·043	1·038	1·033	1·028	1·023	1·018	1·013	1·008	1·003	·998	·993
29·9	1·046	1·041	1·036	1·031	1·026	1·022	1·017	1·012	1·007	1·002	·997
30·0	1·050	1·045	1·040	1·035	1·030	1·025	1·020	1·015	1·010	1·005	1·000
30·1	1·053	1·048	1·043	1·038	1·033	1·029	1·024	1·019	1·014	1·009	1·003
30·2	1·057	1·052	1·047	1·042	1·037	1·032	1·027	1·022	1·017	1·012	1·007
30·3	1·060	1·055	1·050	1·045	1·040	1·036	1·030	1·025	1·020	1·015	1·010
30·4	1·064	1·059	1·054	1·049	1·044	1·039	1·034	1·029	1·024	1·019	1·014
30·5	1·067	1·062	1·057	1·052	1·047	1·042	1·037	1·032	1·027	1·022	1·017
30·6	1·071	1·066	1·061	1·056	1·051	1·046	1·041	1·036	1·031	1·026	1·020
30·7	1·074	1·069	1·064	1·059	1·054	1 049	1·044	1·039	1·034	1·029	1·024
30·8	1·078	1·073	1·068	1·063	1·058	1·053	1·048	1·043	1·037	1·032	1·027
30·9	1·081	1·076	1·071	1·066	1·061	1·056	1·051	1·046	1·041	1·036	1·031
31·0	1·085	1·080	1·075	1·070	1·065	1·060	1·055	1·049	1·044	1·039	1·034

⁂ *The numbers* in the above table have been re-calculated from the formula
perature on the Fahrenheit scale, and *a* the tension of aqueous vapour at t°.
at 60° and 30 inches pressure, V = *v n*.

different Temperatures and under different Atmospheric Pressures.

BAR.	THER. 62°	64°	66°	68°	70°	72°	74°	76°	78°	80°	82°	84°
28·0	·927	·922	·917	·912	·907	·902	·897	·892	·887	·881	·875	·870
28·1	·930	·926	·921	·916	·911	·905	·900	·895	·890	·884	·879	·873
28·2	·934	·929	·924	·919	·914	·909	·904	·898	·893	·887	·882	·876
28·3	·937	·932	·928	·922	·917	·912	·907	·902	·896	·891	·885	·880
28·4	·941	·936	·931	·926	·921	·915	·910	·905	·900	·894	·888	·883
28·5	·944	·939	·934	·929	·924	·919	·914	·908	·903	·897	·892	·886
28·6	·947	·943	·938	·932	·927	·922	·917	·912	·906	·901	·895	·889
28·7	·951	·946	·941	·936	·931	·925	·920	·915	·909	·904	·898	·893
28·8	·954	·949	·944	·939	·934	·929	·924	·918	·913	·907	·901	·896
28·9	·958	·953	·948	·942	·937	·932	·927	·921	·916	·910	·905	·899
29·0	·961	·956	·951	·946	·941	·935	·930	·925	·919	·914	·908	.903
29·1	·964	·959	·954	·949	944	·939	·933	·928	·923	·917	·911	·906
29·2	·968	·963	·958	·952	·947	·942	·937	·931	·926	·920	·914	·909
29·3	·971	·966	·961	·956	·950	·945	·940	·935	·929	·923	·918	·912
29·4	·975	·969	·964	·959	·954	·949	·943	·938	·932	·927	·921	·915
29·5	·978	·973	·968	·962	·957	·952	·947	·941	·936	·930	·924	·919
29·6	·981	·976	·971	·966	·960	·955	·950	·944	·939	·933	·927	·922
29·7	·985	·980	·974	·969	·964	·959	·953	·948	·942	·937	·931	·925
29·8	·988	·983	·978	·972	·967	·962	·957	·951	·946	·940	·934	·928
29·9	·991	·986	·981	·976	·970	·965	·960	·954	·949	·943	·937	·932
30·0	·995	·990	·985	·979	·974	·968	·963	·958	·952	·946	·941	·935
30·1	·998	·993	·988	·983	·977	·972	·966	·961	·955	·950	·944	·938
30·2	1·002	·996	·991	·986	·980	·975	·970	·964	·959	·953	·947	·941
30·3	1·005	1·000	·995	·989	·984	·978	·973	·968	·962	·956	·950	·945
30·4	1·008	1·003	·998	·993	·987	·982	·976	·971	·965	·959	·954	·948
30·5	1·012	1·006	1·001	·996	·990	·985	·980	·974	·969	·963	·957	·951
30·6	1·015	1·010	1·005	·999	·994	·988	·983	·977	·972	·966	·960	·954
30·7	1·018	1·013	1·008	1·003	·997	·992	·986	·981	·975	·969	·963	·957
30·8	1·022	1·017	1·011	1·006	1·000	·995	·990	·984	·978	·972	·967	·961
30·9	1·025	1·020	1·015	1·009	1·004	·998	·993	·987	·982	·976	·970	·964
31·0	1·029	1·023	1·018	1·013	1·007	1·002	·996	·991	·985	·979	·973	·967

$n = \frac{17{\cdot}64\,(h - a)}{460 + t}$, where h is the height of the barometer in inches, t the tem-

If v is any *volume at* t° and h inches pressure, and V the corresponding volume

The Meters used for Measuring the Gas Consumed in Making the Various Testings.

The meters used for measuring the gas consumed in making the various testings, having been certified by the Referees, shall, at periods of not less than seven days, be proved by the Gas Examiners by means of the Referees' cubic-foot measure,—a description of which apparatus, with directions how to use it, is given below. Should a meter show any variation, water must be added or withdrawn until the meter is correct. Every testing place shall have the above-mentioned apparatus, so that the Gas Examiner may employ it whenever he thinks necessary.

No meter other than a wet one shall be used in testing the gas under these instructions.

The Gas Referees' Cubic-Foot Measure.

Description of the Cubic-Foot Measure; the method of fixing it; and directions for verifying the accuracy of the Meters connected with the Photometers and also with the Sulphur and Ammonia Tests.

I.

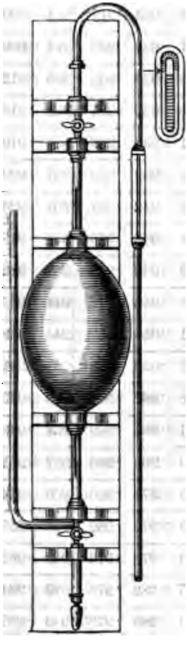


FIG. 102.

This instrument (Fig. 102) is a vessel in form like an elongated egg, made of hardened tin about one quarter of an inch thick, fitted at each end with a narrow glass tube, the joints being made sound with india-rubber packing. The instrument stands in a vertical position, firmly fixed to a strong plank.

At the top of the instrument is a three-way cock, marked on the head of the key with a T, each arm of which shows the direction of a way through the plug; and in the side of this cock there is a small hole or vent, which serves to admit the air when the measure is to be emptied of water. When the T is in its ordinary position communication is closed between the measure and the tube leading from it to the meters, but is open to the external air; with the ⊣ in this position (*i.e.*, with the stem pointing to the *opposite* side of the cock to that in which the vent is drilled) the measure is open to the meters and shut to the air.

At the bottom of the instrument there are two cocks: the small one, when opened, admits water into the measure; the large one, when opened, allows the water to be run off. The former of these cocks is provided with a lever-key, in order to regulate with greater nicety the entrance of the water into the measure.

The cock at the top of the measure is continued by a tin pipe in the form of an arch (bending down to meet the pipe leading to the meters); and at the further end of the arch there is a piece of glass tube, in which a thermometer is hung to show the temperature of the air passing from the measure into the meter.

Affixed round each of the glass tubes fitted to the upper and lower part of the measure there is a narrow strip of paper, which indicates the exact measure of one cubic foot, as tested by the Exchequer standard cubic-foot bottle,—the upper edge of both strips of paper being the true water-line of the measure.

II.

The instrument should be in communication with a tank of water fed by a self-acting supply.

The lower water-level of the tank should be even with the top of the strip of paper marking the "full" line of the vessel; and it is advantageous that the upper water-level should be below the plug of the three-way cock on the measure.

III.

To verify the meters employed in ascertaining the consumption of gas in the photometers, or those employed in the sulphur and ammonia tests, the mode of procedure is as follows:—

Turn the three-way cock at the top of the instrument so as to leave the vent open to the air; and shut the large cock at the bottom of the apparatus. Then open the small lever cock, and allow sufficient water to flow in to fill the lower glass tube up to the water-line. Then turn the upper cock so as to close the vent, while opening the way to the meters.

Next open the cock of the meter which is to be tested—taking care that all the other meters are closed to the cubic-foot measure. Note the exact position of the index hands,—*i.e.*, both the long hand and the 1-foot hand, if it be a photometer meter, or simply the long hand if it be a sulphur meter.

When all is ready, open a communication between the outlet of the meter and the air,—at the same time taking care that all the pressure-gauge cocks are closed. Then proceed gently to open the small lever-cock, and allow the water to flow into the measure, just fast enough to raise the pressure in the siphon pressure-gauge fixed alongside, and in communication with the measure, from half an inch to three quarters. This precaution is necessary to prevent the water being blown out of the meter by excessive pressure.

A meter attached to the photometer should make 12 revolutions of the long hand, and consequently one of the cubic foot hand, by the time the measure is full up to the strip of paper on the upper glass tube. A meter connected with the sulphur test should, in the same time, make one revolution of the long hand.

Should the meter complete the prescribed number of revolutions before the measure is full, then some water must be removed from the meter; if the contrary is the case, then water must be added to the meter. The testing is then to be repeated until the meter is found to register correctly.

The dial of the photometer meters is divided into 50 divisions; and as each revolution indicates one-twelfth of a foot, each division consequently represents the $\frac{1}{600}$ part of a cubic foot; and therefore 6 of those divisions represent 1 per cent.

The dial of the sulphur meters is divided into 100 parts; and as each complete revolution indicates one foot, each division consequently represents 1 per cent.

The difference of an ounce in the quantity of water in the meters will make them register about 1 per cent. either fast or slow.

When the temperature of the cubic-foot measure is higher than the temperature at the outlet of the meter, the meter (if correct) will register a smaller quantity than has actually passed to it from the measure; when the temperature of the measure is lower than that of the meter the quantity registered ought to be greater.

To find the volume which the meter ought to register, when such a difference of temperature exists, divide the tabular number corresponding to the barometric pressure and the temperature of the cubic-foot measure by the tabular number corresponding to the barometric pressure and the temperature of the meter. (See Tables, pp. 250 and 251.)

As to the Mode of Testing the Pressure at which Gas is Supplied.

Testings of pressure shall be made by unscrewing the governor and burner of one of the ordinary public lamps, in such street or part of a street as the controlling authority may from time to time appoint, and attaching in their stead a portable pressure gauge.

Each testing place is provided with a gauge prescribed for this purpose by the Referees, consisting of an ordinary pressure-gauge enclosed in a lantern (Fig. 103), which also holds a candle for throwing light upon the tubes and scale. The difference of level of the water in the two limbs of the gauge is read by means of a sliding scale, the zero of which is made to coincide with the top of the lower column of liquid.

The Gas Examiners having fixed the gauge gas-tight, and as nearly as possible vertical, on the pipe of the lamp, and having opened the cocks of the lamp and gauge, shall read and at once record the pressure shown. From the observed pressure one-tenth of an inch is to be deducted to correct for the difference between the pressure of gas at the top of the lamp-column and that at which it is supplied to the basement of the neighbouring houses.

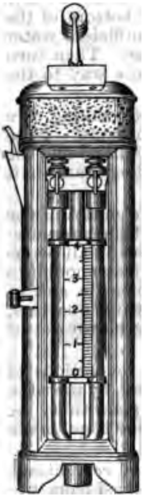


FIG. 103.

PHOTOMETER TABLE.

*Calculated for One Candle. (Mr. Sugg.)**

ion as, per r.	Grains per Hour Consumed by the Sperm Candle.								
	110	111	112	113	114	115	116	117	118
	1·01851	1·02777	1 03703	1·04629	1·05555	1·06481	1·07407	1·08333	1·09259
	·99637	1·00543	1 01449	1·02355	1·03260	1·04166	1·05072	1·05978	1·06884
	·97517	·98404	·99290	1·00177	1·01063	1·01950	1·02836	1·03723	1·04609
	·95486	·96354	·97222	·98090	·98958	·99826	1·00694	1·01562	1·02430
	93537	94387	·95238	·96088	·96938	·97789	·98639	·99489	1·00340
	·91666	·92500	·93333	·94166	·95000	·95833	·96666	·97499	·98333
	·89869	·90686	·91503	·92320	·93137	·93954	·94771	·95588	·96405
	·88141	·88942	89743	·90544	·91346	·92147	·92948	·93750	·94551
	·86477	·87264	·88050	·88836	·89622	·90408	91194	·91981	·92767
	·84876	·85648	·86419	·87191	·87962	·88734	·89506	·90277	·91049
	·83333	·84090	·84848	·85606	·86363	·87121	·87878	·88636	·89393

ion ns, per r.	Grains per Hour Consumed by the Sperm Candle.								
	119	120	121	122	123	124	125	126	127
	1·10185	1·11111	1·12037	1·12962	1·13888	1·14814	1·15740	1·16666	1·17592
	1·07789	1·08695	1·09601	1·10507	1·11413	1·12318	1·13224	1·14130	1·15036
	1·05496	1·06383	1·07269	1·08156	1·09042	1·09929	1·10815	1·11702	1·12588
	1 03298	1 04166	1·05034	1·05902	1·06770	1·07638	1·08506	1·09375	1·10243
	1·01190	1·02040	1 02891	1·03741	1·04591	1·05442	1·06292	1·07142	1·07993
	·99166	1·00000	1·00833	1·01666	1·02499	1·03333	1·04166	1·04999	1·05832
	·97222	·98039	·98856	·99673	1·00490	1·01307	1·02124	1·02941	1·03758
	·95352	·96153	·96955	·97756	·98557	99358	1·00160	1·00961	1·01762
	·93553	·94339	·95125	·95911	·96698	97484	·98270	·99056	·99842
	·91820	·92592	·93364	·94135	·94907	·95679	·96450	·97222	·97993
	·90151	·90909	·91666	·92424	93181	·93939	·94696	·95454	·96212

ion ns, per r.	Grains per Hour Consumed by the Sperm Candle.								
	128	129	130	131	132	133	134	135	..
	1·18518	1·19444	1·20370	1·21296	1·22222	1·23148	1·24074	1·25000	..
	1·15942	1·16847	1·17753	1·18659	1·19565	1·20471	1·21376	1·22282	..
	1·13475	1·14361	1·15248	1·16134	1·17021	1·17907	1·18794	1·19680	.
	1·11111	1·11979	1·12847	1·13715	1·14583	1·15451	1·16319	1·17187	..
	1·08843	1·09693	1·10544	1·11394	1·12244	1·13095	1·13945	1 14795	..
	1·06666	1·07500	1·08333	1·09166	1·10000	1·10833	1·11666	1·12500	..
	1·04575	1·05392	1·06209	1·07026	1·07843	1·08660	1·09477	1·10294	..
	1·02564	1·03365	1·04166	1·04963	1·05769	1 06570	1·07371	1·08173	..
	1·00628	1·01415	1·02201	1·02987	1·03773	1 04559	1·05345	1·06132	..
	·98765	·99537	1·00308	1·01080	1·01851	1 02623	1·03395	1·0416	..
	·96969	·97727	·98484	99242	1·00000	1·00757	1·01515	1·02272	..

Ir. Sugg has also published, in a book form, a series of useful photometrical
from 9·5 to 20 candles.

RULE.—Multiply the number standing beneath the number of grains consumed by the candle, and opposite the number of feet consumed by the gas-burner, by the illuminating power as read off from the scale of the photometer; the product is the correct value of the gas reduced to the standard of 120 grains per hour and 5 cubic feet per hour.

Various Proposed Standards of Light.

The sperm candle has long been considered an unsatisfactory standard, owing chiefly to the shade of colour emitted by it differing somewhat from that of the gas, and the inequality of its rate of consumption.

Various standards of light have been advocated from time to time to supersede the candle, but none of these have hitherto been adopted in this country.

The Carcel lamp is the standard in France, the light being produced by colza oil burning at the rate of 648 grains per hour.

Mr. Keates invented a moderator lamp consuming sperm oil, and yielding a light equal to ten sperm candles, which he advocated as a suitable standard.

More recently Mr. Vernon Harcourt has proposed the use of a gas consisting of "a mixture of air with that portion of American petroleum, which, after repeated rectification, distils at a temperature not exceeding 122° Fahr. The liquid thus obtained consists almost entirely of pentane, the fifth member of the series of paraffines." Burning at the rate of ½ a cubic foot per hour, this gas gives a flame which yields a light equal to that of the standard candle.

The most ingenious standard proposed is that of a portion of the gas flame itself. The credit of the conception is shared by both Mr. Fiddes and Mr. John Methven, who, unaware of each other's investigations, conducted a series of experiments on the same lines.

In the course of his photometrical observations, Mr. Fiddes found that if a circular hole about ¼ inch in diameter were made at a given height in an opaque chimney, and this placed over an argand flame in lieu of the usual glass chimney, the amount of light passing through the hole was a constant quantity, notwithstanding variations in the illuminating power of the gas.

Mr. Methven's researches led him to a similar conclusion, but instead of the circular hole, he adopts a vertical slot 1 inch long and ¼ inch wide, and instead of making this in the chimney, he places an opaque screen, with the slot therein, immediately in front of the light.

The results obtained by Mr. Methven through an exhaustive series of experiments with different qualities of gas, approximate in a remarkable degree, and, though paradoxical at first sight, it is daily becoming more evident that the acceptance of Mr. Methven's light as a standard would be a fairly satisfactory solution of the difficulty. Photometrical observations, also, are greatly simplified by the ease with which it can be used, the saving of time which it effects, and the avoidance of that distraction of mind on the part of the operator, which is inseparable from the employment of candles.

TABLE

Comparing the Specific Gravity of Gas (Air being 1·000) with the Illuminating Power in Standard Sperm Candles.

No. of Cndls.		Spec. Grav.	No. of Cndls.		Spec. Grav.	No. of Cndls.		Spec Grav
10	equal to about	·380	20	equal to about	·508	30	equal to about	·678
11	„	·392	21	„	·522	31	„	·694
12	„	·405	22	„	·537	32	„	·708
13	„	·416	23	„	·550	33	„	·722
14	„	·430	24	„	·565	34	„	·738
15	„	·443	25	„	·585	35	„	·755
16	„	·455	26	„	·605	36	„	·775
17	„	·468	27	„	·625	37	„	·790
18	„	·482	28	„	·645			
19	„	·495	29	„	·662			

VARIATIONS IN THE ILLUMINATING POWER OF GAS.

Most gas managers, in the course of their experience, must have observed variations, sometimes considerable, in the illuminating power of their gas, for which they have been unable satisfactorily to account. These variations are unquestionably due, to a great extent, to changes of atmospheric pressure. When the pressure is augmented the luminosity is increased, and *vice versâ*. To determine this point, Dr. Frankland instituted a series of important experiments, of which the following are the results:—

Pressure of Air in Inches of Mercury.	Observed Illuminating Power.	Pressure of Air in Inches of Mercury.	Observed Illuminating Power.
30·2	100·0	18·2	37·4
28·2	91·4	16·2	29·4
26·2	80·6	14·2	19·8
24·2	73·0	12·2	12·5
22·2	61·4	10·2	3·6
20·2	47·8		

The diminution of luminosity follows a fixed and definite law, which may be thus expressed: The decrease in illuminating power is directly proportional to the decrease of atmospheric pressure. Of 100 units of light emitted by a gas-flame burning in air, 5·1 units are extinguished by each reduction of 1 mercurial inch of atmospheric pressure. On the other hand, if a lightless flame be made to burn under augmented pressure, it becomes luminous. The chief cause of the difference is the increase in the volume, and therefore decrease of the density of those heavy hydrocarbons to which the luminosity of a gas-flame is attributed when the atmospheric pressure is reduced, and *vice versâ*.

TABLE

Showing the Percentage of Loss of Light by Mixing Air with Coal Gas.

Per Cent. Air.	Loss of Light Per Cent.	Per Cent. Air.	Loss of Light Per Cent.
1	6	8	58
2	11	9	64
3	18	10	67
4	26	15	80
5	33	20	93
6	44	30	98
7	53	40	100

JET PHOTOMETER.

The three following instruments, which are each employed to determine the illuminating value of gas, though only approximately correct in their indications, are yet sufficiently trustworthy to render them useful and valuable auxiliaries to the more absolute method of testing already described.

Their great recommendations are their portability, and the ease and celerity with which the illuminating power can be ascertained by their aid.

Their action depends on the relation which the specific gravity of the gas bears to its illuminating power. The flame being kept at a given height, the pressure required, and therefore the rate of consumption of the gas will vary according to its density and consequent illuminating value.

The Jet Photometer.

Lowe's jet photometer, as improved by Sugg and Kirkham (Fig. 104), affords a ready means of ascertaining by a momentary inspection whether the gas being produced is uniform in quality. The apparatus consists of a King's gauge of delicate construction, with its semicircular scale indicating the pressure. A steatite jet having a fine orifice is fixed at the top of this, and the gas issuing therefrom, and being lighted, gives a flame which should be constantly maintained at 7 inches height.

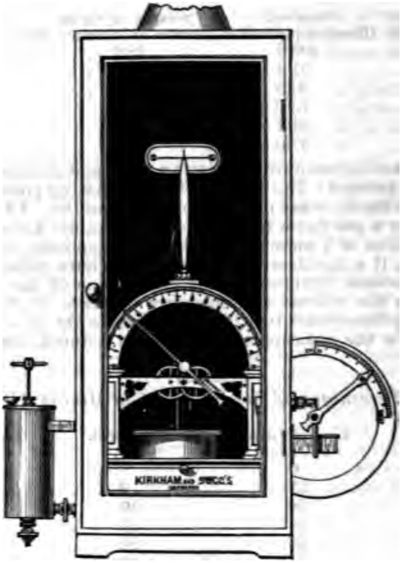
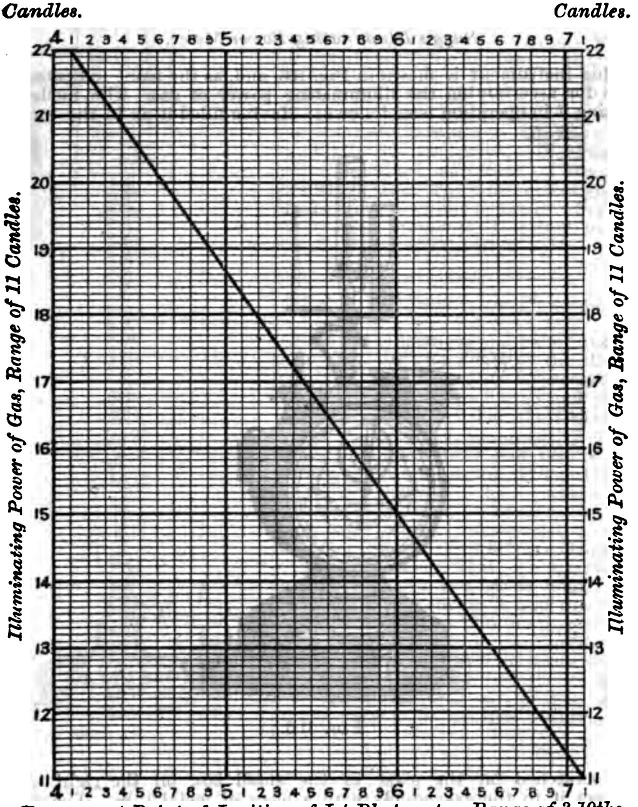


FIG. 104.

The length of the flame is ascertained by a scale of inches marked on the glass door and on the back of the photometer. The pressure required to maintain the flame at the required height being noted, affords the means of determining the illuminating power on reference to the accompanying diagram. (Fig. 105).

Kirkham and Sugg's Retrograde Scale of Jet Photometer maintaining a Standard 7-inch flame from an orifice of certain fixed dimensions.



Pressure at Point of Ignition of Jet Photometer, Range of 3-10ths of an Inch.

Fig. 105.

8 2

For example:—Suppose the pressure necessary to give the 7-inch flame is 5·4 tenths, then on tracing the diagonal line to the point where it intersects the vertical and horizontal lines, it will be found that the reading at the side gives 17·25 candles as the illuminating power.

The gas-tap is shown on the right side of the instrument. The small cylinder on the left side is in communication with the water cistern in the body of the gauge, and contains a compensator, which on being screwed up or down as required, adjusts the water-line so that the pointer of the gauge stands at zero when the gas-tap is closed.

Sugg's Illuminating Power Meter.

This instrument is shown in Fig. 106, and, as the name indicates, is used for ascertaining the illuminating power of gas. The mode of putting it in operation is as follows:—Having filled it up to the water-line scratched on the glass in the small box on the right side, connect it to the gas supply with a piece of metal tube. The inlet is a ground union joint, fixed in the centre of the back of the instrument. Turn the lever so as to make the gas pass through the measuring-drum, and let it get rid of all the air, or other kind of gas

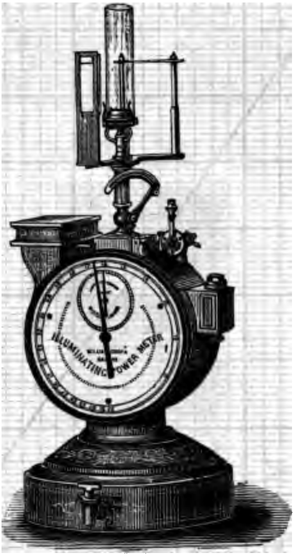


FIG. 106.

in it. Light the burner and adjust the flame to 3 inches in height. Then, when the large hand arrives at 16, change the position of the lever, so as to make the gas pass to the burner without going through the measuring-drum. The large hand will then stop at 16. Wind up the clock by means of the *remontoir* on the top of the meter just in the rear of the dial ring. Start the clock by moving the slide which is on the left of the meter, close to the governor. Then, when the hand of the clock is passing any one of the divisions of the minute, change the position of the lever of the bye-pass, so as to make the gas pass through the meter. When the minute hand has made one complete revolution, stop the meter by means of the lever, in the manner before described, and read off the illuminating power. The minute clock should not be stopped either before or after the observation, unless it is desired to put the clock entirely at rest.

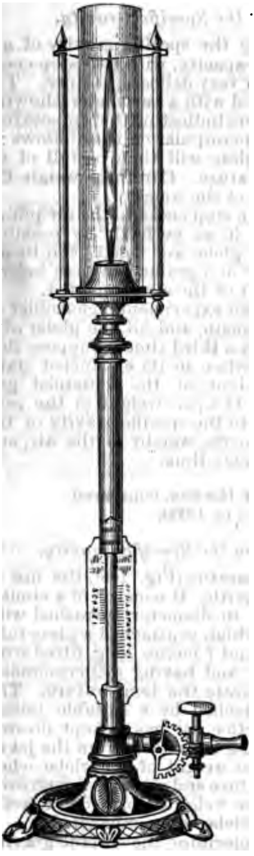


FIG. 107

Thorp and Tasker's Jet Photometer.

This is an ingenious and handy instrument (Fig. 107), for enabling the illuminating value of the gas to be ascertained from inspection at any time and place. It is well understood that the size of an orifice being altered, the quantity of gas passed in a given time will bear a proportion to the size of the orifice (this is the principle on which the aërorheometer is made—a useful instrument by the same inventors for indicating the quantity of gas consumed by different burners, &c.); and further, that the gas flame being maintained at a given height, the quantity of gas consumed, and the pressure will vary as the illuminating power. A movable or floating disc inside the glass tube regulates the size of the orifice, and its position in the tube, corresponding to the graduations of the scale at the side, indicates the illuminating value.

THE SPECIFIC GRAVITY OF GAS.

Specific Gravity a Test of Quality.

If coal gas is free from carbonic acid, sulphuretted hydrogen, and air, specific gravity is a proper test of quality; the denser it is the greater will be its illuminating power; increase in weight and light-giving property being due to the presence of a larger proportion of olefiant gas and the other richer and heavier hydrocarbons.

Ordinary Method of Determining the Specific Gravity.

The apparatus required in determining the specific gravity of gas are a thin glass globe of 100 cubic inches capacity, with two stop-cocks on opposite sides, a good air-pump, and a very delicate balance. The experimental room should also be furnished with a barometer showing the atmospheric pressure, and thermometers indicating the temperature both of the air and gas. The method of manipulation is as follows:—

First.—Open the two stop-cocks; the globe will then be full of air at the atmospheric pressure and temperature. Carefully weigh the globe while in this state, and make a note of the weight.

Second.—Attach the globe by one of the stop-cocks to the air-pump, close the other stop-cock, and exhaust it as perfectly as possible. Having closed the stop-cock, remove the globe and weigh it in its exhausted state. Suppose that it now weighs 31·5 grains less than before, then these 31·5 grains represent the weight of the air abstracted.

Third.—Now attach the globe either to an experimental gasholder or to a gas-pillar connected by a pipe to the main, and fill the globe with the gas. When full, remove it and weigh it a third time. Suppose that the weight is now 14·2 grains more than when in its exhausted state, then these 14·2 grains represent the weight of the contained gas. Then, as 31·5 (the weight of the air) is to 14·2 (the weight of the gas), so is 1·000 (the specific gravity of the air) to the specific gravity of the gas. Or, divide the weight of the gas by the weight of the air, and the quotient is the specific gravity of the gas; thus—

$$\frac{14{\cdot}2}{31{\cdot}5} = {\cdot}450, \text{ specific gravity of the gas, compared with air as unity, or } 1{\cdot}000.$$

Dr. Letheby's Method of Determining the Specific Gravity.

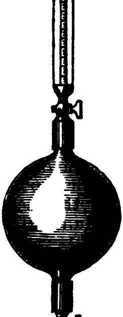


FIG. 108.

With Dr. Letheby's apparatus (Fig. 108), the use of the air-pump is dispensed with. It consists of a similar glass globe, about 6 inches in diameter, furnished with two stop-cocks, to one of which is attached a glass tube half an inch in diameter and 7 inches long, fitted with a jet for burning the gas, and having a thermometer inside of the tube to indicate the temperature. The other stop-cock can be attached by a suitable nozzle to a gas-pillar, and in practice the gas is kept flowing through the apparatus, being consumed from the jet at the upper end. The exact weight of the globe when full of air at mean temperature and pressure is engraved upon it; and a counterpoise weight is provided exactly equal to the weight of the globe when exhausted.

When it is required to determine the specific gravity of the gas, the lower or supply-cock is first closed, and the upper one immediately afterwards. This order is necessary to be observed in the shutting of the cocks, because if the upper one were first closed, the gas within the globe would be at the pressure of the gas within the main, instead of that of the atmosphere. The globe is then placed in the balance and a sufficient number of grains and fractional parts added to the pan containing the counterpoise weight to equalize the beam. Suppose that it takes 15 grains, then these represent the weight of the gas, and say that the globeful of air weighs 35 grains, then—

$$\frac{15}{35} = \cdot429, \text{ the specific gravity of the gas.}$$

But it is necessary in making such observations to correct the volume of gas to mean temperature and pressure, and to allow for the moisture present in all aëriform bodies in contact with water. To these points the following observations apply:—

Corrections for Temperature, Barometric Pressure, and Moisture.

Owing to the contraction and expansion which takes place in the bulk of all aëriform bodies, due to the variations in atmospheric temperature and pressure, it is necessary, when estimating and comparing their volume, to adopt one common temperature and barometric pressure as the standard. The mean temperature of 60° Fahr. and 30 inches of mercury has been adopted as the most convenient, and to this standard their volume is accordingly reduced. For example:

Corrections for Temperature.—All aëriform bodies expand 1-480th part of their volume at 32° Fahr. for every degree of increase of temperature (1-273rd of the volume of the gas at 0° Centigrade for each degree of the same scale). Now suppose it is required to ascertain what volume 1000 cubic feet of gas at 68° will occupy at 60° the mean temperature. We know by the above-mentioned law that a quantity of gas which at 32° is 480 parts, will at 60° become 508 $(60 - 32 = 28 + 480 = 508)$, and at 68°, 516 $(68 - 32 = 36 + 480 = 516)$, then—

$$\frac{1000 \times 508}{516} = 984 \text{ cubic feet.}$$

Or, again, if it is required to know the volume which 1000 cubic feet of gas at 56° will occupy at 60°, then—

$$\frac{1000 \times 508}{504} = 1008 \text{ cubic feet.}$$

Correction for Pressure.—The amount of decrease or increase in volume is inversely as the pressure. To ascertain what volume 1000 cubic feet of gas at 28·5 inches, will occupy when the mercury stands at 30 inches, the mean barometric pressure, then—

$$\frac{1000 \times 28\cdot5}{30} = 950 \text{ cubic feet.}$$

Or, again, if it is desired to ascertain the volume which 1000 cubic feet of gas at 30·6 inches will occupy at 30 inches, then—

$$\frac{1000 \times 30\cdot6}{30} = 1020 \text{ cubic feet.}$$

Or,

Correcting at once for Temperature and Pressure.—Suppose it is required to ascertain what volume 1000 cubic feet of gas at 72° temperature and 29·8 inches pressure will occupy at standard temperature and pressure, then—

$$1000 \times \frac{508}{520} \times \frac{29\cdot8}{30} = 970\cdot5 \text{ cubic feet.}$$

Correction for Moisture.—It has been proved by experiment that one cubic inch of permanent aqueous vapour at the mean temperature of 60°, and the mean pressure of 30 inches, weighs ·1929 grains, and the following table, founded on the researches of Dalton and Ure, and given by Faraday in his "Chemical Manipulations," shows the proportion by volume of aqueous vapour existing in any gas standing over or in contact with water, at the different temperatures indicated, and at a mean barometric pressure of 30 inches.

Temp. Deg. Fahr.	Proportion of Vapour in One Volume of Gas.	Temp. Deg. Fahr.	Proportion of Vapour in One Volume of Gas.	Temp. Deg. Fahr.	Proportion of Vapour in One Volume of Gas.
40	·00933	54	·01533	68	·02406
41	·00973	55	·01586	69	·02483
42	·01013	56	·01640	70	·02566
43	·01053	57	·01693	71	·02653
44	·01093	58	·01753	72	·02740
45	·01133	59	·01810	73	·02830
46	·01173	60	·01866	74	·02923
47	·01213	61	·01923	75	·03020
48	·01253	62	·01980	76	·03120
49	·01293	63	·02060	77	·03220
50	·01333	64	·02120	78	·03323
51	·01380	65	·02190	79	·03423
52	·01426	66	·02260	80	·03533
53	·01480	67	·02330		

To determine by means of this table the quantity of aqueous vapour present, it is necessary to multiply the volume of the gas by the tabular number corresponding to the temperature, thus:—Suppose 100 cubic inches of gas weigh 16 grains at the temperature of 72°, and at mean barometric pressure, then according to the table the volume of aqueous vapour present is—

$$100 \times {\cdot}02740 = 2{\cdot}740 \text{ cubic inches.}$$

This corrected to mean temperature will be—

$$2{\cdot}74 \times \frac{480 + 28}{480 + 40} = 2{\cdot}677 \text{ cubic inches.}$$

Now with respect to the volume of the gas, 100 cubic inches at 72° are equal to—

$$100 \times \frac{480 \times 28}{480 \times 40} = 97{\cdot}7 \text{ cubic inches at a temperature of } 60^{\circ}.$$

Hence, 97·7 — 2·677 = 95·023 cubic inches, the volume of dry gas at mean temperature and pressure.

To arrive at the weight of the volume of dry gas, the volume of aqueous vapour must be multiplied by ·1929 grains, the weight of a cubic inch of permanent aqueous vapour, as before stated, and the product deducted from the total weight of 16 grains; thus,—

$$16 - (2{\cdot}677 \times {\cdot}1929) = 15{\cdot}483 \text{ grains.}$$

Then for the weight of 100 cubic inches of dry gas, we have—

$$\frac{15{\cdot}483 \times 100}{95{\cdot}023} = 16{\cdot}294 \text{ grains.}$$

And as 100 cubic inches of air at mean temperature and pressure weigh 31 grains, we have—

$$\frac{16{\cdot}294}{31} = {\cdot}525, \text{ the specific gravity of the gas.}$$

If, instead of making the correction for moisture, it is preferred to dry the gas as it passes into the globe, this may be done by causing it to flow through a glass tube half an inch in diameter and about 18 to 20 inches long, containing pieces of chloride of calcium, that substance having a strong affinity for moisture. Before using, the chloride of calcium should be fused in an earthenware crucible at a low temperature, then poured on a clean stone surface, and as soon as cold, broken in pieces and put into the tube. The gas in passing through the tube to fill the globe should be made to travel slowly, about 15 minutes being the usual time allowed.

Mr. Wright's Method of Determining the Specific Gravity.

For ascertaining the specific gravity of gas, Mr. Wright used a light balloon (Fig. 109), capable of containing one cubic foot, or 1728 cubic inches.

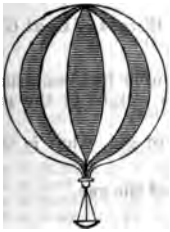


FIG. 109.

His directions for performing the experiment are as follows:—

Expel the air from the balloon by folding it in the form in which it is first received, ascertain the weight of the balloon and car, fill the balloon with gas, insert the stopper, and put as many grains* in the car as will balance it in the air; add the number of grains which it carries to the weight of the balloon, and deduct the amount from the tabular number corresponding to the degree of temperature indicated by the thermometer, and the pressure indicated by the barometer (pp. 250-1), divide the result by the tabular number due to the temperature and pressure of the gas (to ascertain which, allow the gas to blow upon the bulb of the thermometer until the mercury is stationary), and the three first figures are the specific gravity.

EXAMPLE I.

Temperature of the air	70°	Tabular number 924.
Barometer.	28·5 in.	
Temperature of the gas	56°	Tabular number, 959.
Barometer always the same as air,	28·5 in.	

Weight of balloon and grains in car, 560.

Then—

$$\frac{924 - 560}{959} = {\cdot}379, \text{ the specific gravity.}$$

---

[*] The weights used are not troy grains, 100 of them being equal to 53·56 troy grains; they are each equal to 1·728 cubic inches of air, when the barometer is at 30 inches, and the thermometer at 60°.

Example II.

Temperature of the air . . .	40°	Tabular number, 1067.
Barometer	30·5 in.	
Temperature of the gas . . .	62°	Tabular number, 1012.
Barometer always the same as air	30·5 in.	

Weight of balloon and grains in car, 560.

Then—

$$\frac{1067 - 560}{1012} = \cdot 501, \text{ the specific gravity.}$$

To Find the Weight of any Quantity of Gas in Pounds, the Specific Gravity being known.

Rule.—Multiply the quantity in feet by the specific gravity, and the product by ·0766, and the answer will be the weight of gas in lbs.

Example.—What is the weight of 9400 cubic feet of gas, its specific gravity being ·480?

$$9400 \times \cdot 480 \times \cdot 0766 = 345 \cdot 62 \text{ lbs. of gas.}$$

Handy Rule for Ascertaining (approximately) the Weight of Coal Gas in a Holder.

Rule.—Multiply the number of *thousands* of cubic feet contained in the holder by 37, and the product will be the weight of the gas in lbs.

Example.—A holder contains 54,000 cubic feet of gas, what is the weight of the gas?

$$54 \times 37 = 1998 \text{ lbs., approximate weight of the gas.}$$

THE USE OF GAS FOR COOKING, HEATING, AND MOTIVE POWER.

The use of gas for cooking, heating and motive power has made rapid strides of recent years, and the appliances for these purposes, which are of the most numerous and varied kind, are of great excellence, whilst improvements are constantly being effected therein.

For the manufacture of the different apparatus, new industries have sprung into existence. For domestic and greenhouse use there are numberless heating stoves of superior design and workmanship, and in cooking stoves and ovens there is equal variety.

The gas engine already successfully competes with the steam motor for all purposes where the power required to be exerted is intermittent, and within moderate limits.

For handiness in application, and cleanliness and safety in use, gas as a fuel is unsurpassed.

Taking its advantages in these respects into account, there is economy in its employment even when, as in scattered districts, its price per 1000 cubic feet may be considered high. In towns where the price of gas is comparatively low, there is a positive economy in its adoption, beyond the special recommendations named.

One of the best, perhaps the very best method of reducing the proportion which capital expenditure in gas works bears to revenue, is to cultivate a day consumption of gas, by affording facilities for and encouraging in every legitimate way the use of gas for cooking, heating, and motive power.

This policy, if pursued to a successful issue, is virtually to reduce the percentage of capital in the proportion of such consumption, because the plant is brought to bear in earning profit during the daylight as well as in the lighting hours.

The following experiments, showing the advantages of cooking by means of gas, are quoted by Mr. William Carr, in his article on this subject in "King's Treatise," vol. iii., pp. 232-4:—

COOKING BY MEANS OF GAS.

(Mr. Magnus Ohren, in his work "On the Advantages of Gas for Cooking and Heating.")

Gas at 4s. 5d. per 1000 cubic feet.

Joint.	Weight.		Time.		Weight when Cooked.		Weight of Dripping.		Loss of Weight.		Gas Used.	Cost of Gas.
	lbs.	ozs.	h.	m.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	c. ft.	d.
Leg of Mutton .	8	1½	2	20	7	5	0	5	0	7½	41	2·17
Rib of Beef . .	10	14	2	37	9	10¾	0	5¼	0	14	46	2·43
Leg of Mutton .	9	7	2	30	8	6	0	7½	0	9½	42	2·22
Rib of Beef . .	11	0	2	45	9	13	0	4½	0	14½	48	2·54
	39	6½	..		35	2¾	1	6¼	2	13½	177	9·36

Coal at 22s. per ton. (Mr. Magnus Ohren.)

Joint.	Weight.		Time.		Weight when Cooked.		Weight of Dripping.		Loss of Weight		Coal used.	Cost of Coal.	Cost of Wood.	Total Cost.
	lbs.	ozs.	h.	m.	lbs.	ozs.	lbs.	ozs.	lb.	oz.	lbs.	d.	d.	d.
Leg of Mutton .	8	1½	2	50	7	0¾	0	8	0	7¾	28½	3·36	0·50	3·86
Rib of Beef . .	10	14	2	45	9	10¾	0	5	0	14¼	29	3·42	0·50	3·92
Leg of Mutton .	9	12	2	30	8	0	0	10	1	2	28	3·30	0·50	3·80
Rib of Beef . .	13	2	2	50	11	13	0	6	0	15	30	3·53	0·50	4·03
	41	13½	..		36	8½	1	13	3	7	115½	13·61	2·00	15·61

These experiments were made fourteen years ago, with the imperfect apparatus of that time. The following were made in 1879-80:—

Gas at 2s. 6d. per 1000 cubic feet. (*Mr. H. Woodall.*)

No.	Dimensions of Oven.	Price.	Weight of Uncooked Leg of Mutton.	Gas consumed	Other work performed (if any).	Weight of Cooked Meat.	Weight of Dripping.	Actual Loss of Weight.	Percent. on Joint.	Cost of Gas at 2s. 6d. per 1000 cubic ft.	Quality of Cooking.	—
	in. in. in.	£ s. d.	lbs. oz.	ft.		lbs. oz.	lbs. oz.	lbs. oz.				
1	24 × 14 × 15	5 0 0	9 12	24	..	6 13	2 2	0 13	8·25	¾d.	Excellent.	..
2	23 × 15 × 13	7 10 0	10 14	25½	..	8 9	1 13	0 8	4·50	¾d.	Excellent.	..
3	23 × 15 × 13	7 10 0	..	23	Six loaves bread baked, total weight 22 lbs.	..	..	..	..	¾d.	Excellent.	..
4	23 × 15 × 13	7 10 0	..	25	Six chickens roasted.	..	..	..	..	¾d.	Excellent.	..
5	24 × 13	6 0 0	9 8	37	..	7 10	1 5	0 9	6·00	1⅛d.	Well done.	..
6	20½ × 12½ × 14½	4 10 0	9 5	24	..	7 9	1 8	0 7	5·00	¾d.	Bad and very underdone.	..
7	18½ × 16 × 25	7 5 0	8 8	31	..	7 4	0 10	0 10	7·30	nearly 1d.	Rather underdone near bone.	..
8	26 × 18½ × 18	6 6 0	8 10	55	..	6 5	1 6	0 15	10·80	1½d.	Excellent.	..
9	30 × 17 × 16	8 0 0	10 10	32	Bread baked.	7 10	2 1	0 15	8·80	1d.	Good but rather underdone near bone.	..
10	23 × 15 × 14	3 8 0	8 14	28	..	7 7	0 15	0 8	5·60	over ¾d.	Rather underdone.	..
11	34 × 22 × 18	5 0 0	8 10	63	..	6 1	1 7	1 2	13·00	nearly 2d.	Excellent.	Reflector.
12	22 × 15 × 12½	4 2 0	9 2	35	Seventy tarts and three loaves.	6 8	1 7	1 8	10·25	over 1d.	Underdone.	Reflector.
13	17 × 18 × 24	10 0 0	9 14	40	..	7 8	1 9	0 13	8·25	1¼d.	Well done.	..
14	33 × 23 × 24	6 0 0	36 6	121	..	27 14	5 0	3 8	9·50	3¼d.	Well done.	..
15	20½ × 14 × 14	4 0 0	10 9	40	..	7 7	1 13	1 5	12·50	1¼d.	Well done.	..
16	..	..	8 15	40	Bread baked.	6 9	1 5	1 1	11·75	1¼d.	Well done.	Reflector.

Gas at 2s. 6d. per 1000 cubic feet. (*Mr. Robinson.*)

No.	Dimensions of Oven.	Price.	Weight of Uncooked Leg of Mutton.	Gas consumed	Other work performed (if any).	Weight of Cooked Meat.	Weight of Dripping.	Actual Loss of Weight.	Percent. on Joint.	Cost of Gas at 2s. 6d. per 1000 cubic ft.	Quality of Cooking.	—
..	14 × 14 × 25	6 6 0	8 2	24½	..	5 14½	1 8½	1 0	12·33	¾d.	Excellent.	..

Calculating Mr. Ohren's experiments with coals at the price of 16s. 6d. per ton, and gas at 3s. per 1000 cubic feet, taking the third experiment in each case, and reducing Nos. 1 and 2 in Mr. Woodall's table and Mr. Robinson's experiment to the same standard of comparison, Mr. Carr obtains the following results:—

Gas at 3s. per 1000 cubic feet. Coal at 16s. 6d. per ton.

	Dimensions of Oven.	Price.	Weight of Uncooked Leg of Mutton.	Gas Consumed.	Weight of Cooked Meat.	Weight of Dripping.	Actual Loss of Weight.	Per cent. on Joint.	Cost of Gas at 3s. per 1000 cub. ft.	Quality of Cooking.	Cost of Coal at 16s. 6d. per ton.	Cost of Wood.	Total Cost.
	in. in. in.	£ s. d.	lbs. oz.	ft.	lbs. oz.	lbs. oz.	lbs. oz.		d.		d.	d.	d.
Ohren's Experiment (Coal, 16s. 6d.)	..	..	9 12	..	8 0	0 10	1 2	11·53	..	..	2·47	·50	2·97
Ditto (Gas, 3s.) . .	..	..	9 7	42	8 6	0 7½	0 9½	6·29	1·50	..	..	..	..
Woodall's Experiment	24 × 14 × 15	5 0 0	9 12	24	6 13	2 2	0 13	8·25	·86	Excellent	..	..	..
Ditto ditto	23 × 15 × 13	7 10 0	10 14	25·5	8 9	1 13	0 8	4·50	·91	Ditto	..	..	..
Robinson's ditto .	14 × 14 × 25	6 6 0	8 2	24·2	5 14½	1 3½	1 0	12·33	·87	Ditto	..	..	..

THE RESIDUAL PRODUCTS.

It is daily becoming more imperative on the Gas Manager to do all that in his power lies to promote the interests of the undertaking under his charge by utilizing the residual products of gas manufacture to the utmost extent.

It is a remarkable fact that there are no waste products in a properly conducted gas works. The coke, breeze, tar, ammoniacal liquor, sulphur, spent lime, retort carbon, and even the clinker and ash from the furnaces are all marketable, and therefore of more or less value. The spent heat from the retort bench is even utilized where the regenerative system is applied.

Coke and Breeze.

Coke, as ordinarily produced, is not well adapted for domestic use, for kitcheners, for use in greenhouses, or stoves in general; and, in consequence, its sale is often restricted. To render it suitable for these purposes it requires to be broken into pieces of smaller and more uniform size.

Wherever means have been adopted for this purpose, the article has been found to command a ready sale; and instead of mountains of coke in every available corner of the works, the material is cleared out almost as quickly as it is produced.

The labour and inconvenience and enormous waste attendant on stacking are thus avoided, the premises can be kept in better order, and the revenue is augmented.

For breaking the coke by hand, Mr. Bennett recommends a hammer of the form shown in Fig. 110, with a chisel edge at one end, and four prongs at the other.

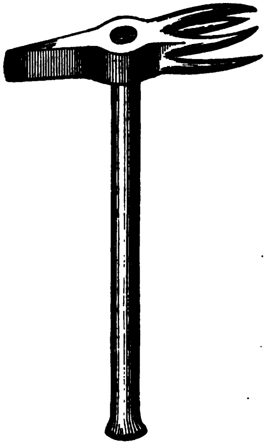


FIG. 110.

A machine for breaking coke is made by Messrs. Smith, Beacock and Tannett, of Leeds. This is used by Mr. Sellers at the York Gas Works, who gives the cost, and describes the advantages attending its use.

"The engine (a 4-horse vertical) and breaker, and fitting up of same, cost £143; being, for the engine, £108, the breaker, £28, and fitting up, £7. By placing the engine and breaker upon one frame, so that both could be moved upon one set of wheels, the cost would be materially reduced, and the working very much improved. The machine, when at full work, will break 20 tons of coke per day. We have one man to look after the engine, and two to feed the machine; but as the first named is not fully occupied with the engine, he assists the other two in helping carters to put the broken coke into bags, &c., the net cost of all which adds 9d. per ton to the price. Then in breaking a ton of coke, about 1 cwt. passes through the screen, and is sold as breeze *at 1s. 6d. per ton*, or, say, 1d. per cwt. The real result, therefore, of *breaking coke* stands thus: We sell our unbroken coke at 10s. per ton, nd broken at 10s. 8d.; the 8d. added being 9d. per ton for labour, and ke converted into breeze by breaking, less 1d. received for breeze per n of coke broken. The cost of maintenance of engine and breaker we nsider is more than recouped by, first, the saving of labour that ould have been employed in loading the coke if it had not been roken; secondly, the saving of the cost in labour and depreciation of acking the coke if it were not sold; and, thirdly, the advantage gained getting rid of the coke, so as to enable us to maintain our price of s. per ton, for upon our annual make of coke for sale a reduction of s. per ton would inflict a loss of £500 a year."

Another excellent coke breaker is that devised by Messrs. Thomas nd Somerville. This machine requires very little power to drive it, nd the waste of coke by its use is remarkably small. At a recent trial f the machine at the Old Kent Road works, the following results ere obtained:—

	s.	d.
500 feet of gas consumed by a 2-horse power gas-engine, at cost price of gas delivered in holder	0	9
Oil and cotton waste	0	6
Two men supplying machine with large coke, and shovelling up broken, at 4s. 6d.	9	0
Interest and wear and tear (say)	0	3
Total per day	10	6

	s.	d.
For 80 tons of coke broken per day at the rate of . . .	0	1½
Add for loss by dust and waste, 1 cwt., with price of coke at (say) 13s. 4d. per ton	0	8
Cost of breaking, per ton	0	9½

The coke thus manipulated finds a ready and constant market as uickly as it is produced, the result being an average net gain of 1s. 6d. er ton of coke.

Coke, when slaked with water, weighs from 20 to 25 per cent. more an when unslaked.

A ton of coke is about a chaldron and a half.

A chaldron of coke varies in weight from 12½ to 15 cwt.

For the quantity of coke produced by different coals, see the tables on ages 4 to 44.

Coal Tar.

The yield of tar from coal per ton in gas works ranges up to 2 gallons, and from cannel up to about 17 gallons. The average production in gas works throughout the country will not exceed 11 gallons er ton. The total production of coal tar in the United Kingdom is robably about 500,000 tons.

The utilization of the tar for its products is not pursued at many as works, though it is done at a few, and if well managed it is a source f profit.

Considerably more skill and care are required in the distillation of ar than in the manufacture of sulphate of ammonia; nevertheless, it s safe to predict that before many years have elapsed this branch of ractical chemistry will be widely practised on those gas works where here is space and convenience.

The manufacture on gas works may be wisely restricted to the distillation of the tar for the light and heavy oils, and the production of pitch.

The principal dangers to be apprehended in the process are the leaking or boiling over of the stills and the firing of vapours, causing conflagration; and the stoppage of the pipe passages with accretions of solid matter, chiefly naphthaline, resulting in explosion; but these dangers can be minimized, or altogether averted, under proper supervision, and by the use of efficient apparatus.

The specific gravity of tar produced from ordinary coal ranges from 1·120 to 1·150; that from cannel coal from ·980 to 1·060.

TABLE

Showing about the Average Proportion of the several Products obtained from the Distillation of 10,000 *gallons of Coal Tar.* (*Dr. Letheby.*)

Ammoniacal liquor	240·0 gals.	Solvent naphtha	41·8 gals.
40 per cent. benzole	34·4 ,,	Last runnings	12·0 ,,
90 ,, ,,	53·1 ,,	Dead oil	3018·7 ,,
Pitch	36 tons		

TABLE

Showing the Average Percentage of the Products Obtained from 100 *Tons of Coal Tar.* (*Roscoe.*)

	1	2	
Naphtha	3·0	2·0	per cent.
Light oils and carbolic acid	1·5	0·8	,,
Heavy oils, naphthaline, anthracene	35·0	25·0	,,
Pitch	50·0	60·0	,,
Water and loss	10·5	12·2	,,
	100·0	100·0	

Mr. C. Greville Williams remarks ("King's Treatise," vol. iii., p. 281) that—"The working results to be obtained from a charge of 1200 gallons vary so greatly, according to the nature of the tar and the care with which the distillation has been made, that it is exceedingly difficult to give any average which will be satisfactory to distillers in different parts of the country. The following figures are placed side by side as extreme cases":—

		Lancashire: (Watson Smith.)	London: (Chemistry as applied to the Arts and Manufactures.)
Ammoniacal liquor	gallons	30	50
First light oils	,,	33	20
Second light oils	,,	157	20
Creosote oils	,,	104	250
Anthracene oils	,,	229	50
Pitch	tons	3·25	4

Tar Pavement.

This is made of the breeze, ashes, and clinker of gas works and mill furnaces, along with shingle or coarsely-ground granite, mixed with coal tar.

A coke fire is first made on the ground, and the solid ingredients *cessed in a heap* round and over it, layer after layer being gradually added as the heat penetrates through the mass, until sufficient bulk of the material is ready.

If preferred, or if a large quantity of material has to be dried and heated, a raised sheet-iron floor may be made, supported on bricks, with the coke fire underneath; or a permanent fire-brick floor may be constructed, ramified with flues underneath leading to a chimney, and having a fire grate at one end.

In the meantime, whilst the solid ingredients are being dried and heated, the tar is being boiled, and, when ready, the two are taken and mixed together in small heaps (say about three ordinary barrow loads) in the proportion by measure of 1 part tar to 7 parts solid.

The whole is then turned over immediately, whilst hot, and thoroughly mixed, until every particle of the solid ingredients has received a coating of tar.

The mixed material is then sorted into three separate heaps of graduated fineness, by passing it through two sieves with ¾-inch and ⅜-inch meshes respectively. It is now ready for use, and may be laid down at once, or kept in stock for a short time until required.

It is preferred by some to sort the solid ingredients before mixing with the tar, as the latter is liable to clog the sieves. In this case an ordinary screen, ¾ inch between the bars, and supported at an angle, is employed; and all that passes through it is afterwards riddled through a ⅜-inch sieve.

The three different grades of material are then dried and made hot as described, and thoroughly mixed with hot tar in these proportions:—

1. Coarse material	1 part tar 9 parts solid	or 24	gals. tar to	1	ton solid.
2. Riddlings . .	1 part tar 7 parts solid	or 30	„	1	„
3. Fine material	1 part tar 6 parts solid	or 36	„	1	„

The footpath being properly kerbed, the upper edge of the stones standing 3 inches above the solid bottom of the path, the rough prepared material, No. 1, is put down 2 inches thick; then No. 2 about ⅝ inch thick, and finally No. 3 about ⅜ inch thick. Each layer as it is put down being rolled with a 10-cwt. roller until thoroughly consolidated; corners which cannot be reached by the roller, must be consolidated by punning. Derbyshire spar or fine granite sprinkled over the surface improves the appearance of the pavement.

Three tons of the rough (No. 1) and 1½ tons of the fine prepared material (Nos. 2 and 3) will cover 60 square yards, or a footpath 2 yards wide and 30 yards long.

Ammoniacal Liquor.

The amount of liquor obtained up to the outlet of the scrubbers, per ton of coal carbonized, varies from 15 to 45 gallons of 10 oz. strength, depending on the class of coal used, and the efficiency of the apparatus for arresting the ammonia.

The product of ammoniacal water, when treated with sulphuric acid, is sulphate of ammonia; when treated with muriatic or hydrochloric acid, it is muriate of ammonia, or sal ammoniac.

The manufacture of sulphate of ammonia from the ammoniacal liquor is fast becoming general in gas works, and properly so, as the process is both simple and profitable. That it must be more profitable to use the liquor at the place of production than at a distance away, is evident, taking into account the saving in the cost of transport of a bulky material.

The apparatus required is neither complicated nor costly; the process is free from danger (though fatal accidents have occurred through carelessness, or the use of imperfect appliances), and an intelligent labourer can learn it in less than a week's time.

In actual practice (using round figures) it is found that—

1 ton of average gas coal yields	28 lbs.	of sulphate	of ammonia.
100 tons ,, ,,	1¼ tons	,,	,,
10½ tons (2294 gals.) ammoniacal liquor, 5° Twaddel, yield	1 ton	,,	,,

The strength, and consequent value, of ammoniacal liquor, is commonly ascertained by Twaddel's hydrometer, and also by the quantity of sulphuric acid of the specific gravity 1845 required to neutralize the ammonia contained in one gallon.

Each degree of Twaddel is equal, as nearly as possible, to 2 oz. of acid per gallon of the liquor; hence arises the description of its value:—

Water of	5	degrees Twaddel	is called	10-oz. liquor
,,	6	,,	,,	12 ,,
,,	7	,,	,,	14 ,,

And so on, at the rate of 2 ounces for each degree, so that 10 oz., 12-oz., or 14 oz. liquor means ammoniacal liquor of such a strength that 10-oz., 12 oz., or 14 oz. of sulphuric acid, of the specific gravity 1845, are required to neutralize the ammonia contained in a gallon of it.

To convert degrees of Twaddel's hydrometer into specific gravity, multiply the number of degrees by 5, and add 1000 to the product.

EXAMPLE.—Twaddel $6 \times 5 + 1000 = 1030$ specific gravity.

To convert specific gravity into degrees of Twaddel, deduct 1000 from the specific gravity, and divide the remainder by 5.

EXAMPLE.—Specific gravity $1030 - 1000 \div 5 = 6$ degrees of Twaddel.

To find the weight of a gallon of ammoniacal liquor of any strength, find the specific gravity by the above rule. This will represent the number of ounces avoirdupois in weight per cubic foot. Divide by 16 for the number of pounds per cubic foot, and by 6·25 (gallons per cubic foot) for the weight of a gallon of the liquor.

EXAMPLE.—Required weight per gallon of 10-oz. liquor (5° Twaddel).

$(5 \times 5) + 1000 = 1025$, specific gravity and weight per cubic foot in ounces avoirdupois.

$$\frac{1025}{16} = 64{\cdot}063 \text{ lbs. per cubic foot.}$$

$$\frac{64{\cdot}063}{6{\cdot}25} = 10{\cdot}25 \text{ lbs. weight per gallon of 10 oz. liquor.}$$

It is well-known that the greater the proportion of ammoniacal gas contained in a pure solution, the less the density or specific gravity of such solution. How then, it may be asked, is the apparent contradiction to be explained, that the larger the quantity of ammonia contained in gas liquor, the greater the density?

The explanation is to be found in the circumstance that gas liquor is not a solution of ammonia pure and simple, but contains other gases in solution, and in combination with the ammonia in the form of salts, which increase its specific gravity; and the more ammonia liquor contains, the greater is its power of arresting and absorbing such other gases.

It is by reason of this latter-mentioned fact that Twaddel's hydrometer *is tolerated* as a gauge of the strength and value of the ammoniacal liquor of gas works. At the best, however, its employment for this purpose is very unsatisfactory.

The method of testing by saturating the liquor with sulphuric acid is an improvement on the hydrometer; but even that is imperfect, as has been pointed out by Mr. Greville, who ascertained by experiments on 9 different samples of liquor that an average of 22·5 per cent. of the ammonia present in combination was not indicated by the acid.

The mode of testing by Mr. Thomas Wills meets the difficulty. His plan is to mix with the liquor a caustic alkali for which the acids of the salts contained in the liquor have a stronger affinity than for the ammonia with which they are combined. On the mixture being strongly heated, the salts are decomposed in presence of the caustic alkali, and the ammonia is driven off in the gaseous state, and being conveyed into a solution of sulphuric acid is secured as sulphate of ammonia. This and the other methods of testing are fully detailed by Mr. Hartley in his *brochure* on "Ammonia Liquor Tests."

TABLE

Showing the Specific Gravity, Weight per Cubic Foot, Weight per Gallon, and Ounce Strength of Ammoniacal or Gas Liquor of different degrees Twaddel.

Degrees Twaddel Liquor.	Spec. Gravity, and Weight per Cubic Foot in Ounces Avoirdupois.	Weight per Gallon. lbs.	Ounce Strength.	Degrees Twaddel Liquor.	Spec. Gravity, and Weight per Cubic Foot in Ounces Avoirdupois.	Weight per Gallon. lbs.	Ounce Strength.
0	1000	10·0	0	12½	1062·5	10·625	25
½	1002·5	10·025	1	13	1065	10·65	26
1	1005	10·05	2	13½	1067·5	10·675	27
1½	1007·5	10·075	3	14	1070	10·7	28
2	1010	10·1	4	14½	1072·5	10·725	29
2½	1012·5	10·125	5	15	1075	10·75	30
3	1015	10·15	6	15½	1077·5	10·775	31
3½	1017·5	10·175	7	16	1080	10·8	32
4	1020	10·2	8	16½	1082·5	10·825	33
4½	1022·5	10·225	9	17	1085	10·85	34
5	1025	10·25	10	17½	1087·5	10·875	35
5½	1027·5	10·275	11	18	1090	10·9	36
6	1030	10·3	12	18½	1092·5	10·925	37
6½	1032·5	10·325	13	19	1095	10·95	38
7	1035	10·35	14	19½	1097·5	10·975	39
7½	1037·5	10·375	15	20	1100	11·0	40
8	1040	10·4	16	20½	1102·5	11·025	41
8½	1042·5	10·425	17	21	1105	11·05	42
9	1045	10·45	18	21½	1107·5	11·075	43
9½	1047·5	10·475	19	22	1110	11·1	44
10	1050	10·5	20	22½	1112·5	11·125	45
10½	1052·5	10·525	21	23	1115	11·15	46
11	1055	10·55	22	23½	1117·5	11·175	47
11½	1057·5	10·575	23	24	1120	11·2	48
12	1060	10·6	24	25	1125	11·25	50

It will be seen by the above that the weight of the liquor in pounds avoirdupois per gallon is obtained by simply placing the decimal point after the first two figures of the number representing the specific gravity. Thus, liquor of 1025 specific gravity is 10·25 lbs.; and of 1087·5 specific gravity is 10·875 lbs. weight per gallon.

Each 5 degrees Twaddel represent a quarter of a pound additional weight per gallon; 20 degrees equal one pound.

In Beaumé's hydrometer, which was the first instrument of the kind, the divisions are equidistant, and it has two modes of graduation according as it is intended for liquids heavier or lighter than water. This instrument is the one principally in use on the Continent.

Beaumé's Hydrometer Compared with Specific Gravity.
For Liquids Heavier than Water.

Degrees Beaumé.	Specific Gravity.	Degrees Beaumé.	Specific Gravity.	Degrees Beaumé.	Specific Gravity.
0	1·000	26	1·206	52	1·520
1	1·007	27	1·216	53	1·535
2	1·013	28	1·225	54	1·551
3	1·020	29	1·235	55	1·567
4	1·027	30	1·245	56	1·583
5	1·034	31	1·256	57	1·600
6	1·041	32	1·267	58	1·617
7	1·048	33	1·277	59	1·634
8	1·056	34	1·288	60	1·652
9	1·063	35	1·299	61	1·670
10	1·070	36	1·310	62	1·689
11	1·078	37	1·321	63	1·708
12	1·085	38	1·333	64	1·727
13	1·094	39	1·345	65	1·747
14	1·101	40	1·357	66	1·767
15	1·109	41	1·369	67	1·788
16	1·118	42	1·381	68	1·809
17	1·126	43	1 395	69	1·831
18	1·134	44	1·407	70	1·854
19	1·143	45	1·420	71	1·877
20	1·152	46	1·434	72	1·900
21	1·160	47	1·448	73	1·944
22	1·169	48	1·462	74	1·949
23	1·178	49	1·476	75	1·974
24	1·188	50	1·490	76	2·000
25	1·197	51	1·495		

Beaumé's Hydrometer Compared with Specific Gravity.
For Liquids Lighter than Water.

Degrees Beaumé.	Specific Gravity.	Degrees Beaumé.	Specific Gravity.	Degrees Beaumé.	Specific Gravity.
10	1·000	27	0·896	44	0·811
11	0·993	28	0·890	45	0·807
12	0·986	29	0·885	46	0·802
13	0·980	30	0·880	47	0·798
14	0·973	31	0·874	48	0·794
15	0·967	32	0·869	49	0·789
16	0·960	33	0·864	50	0·785
17	0·954	34	0·859	51	0·781
18	0·948	35	0·854	52	0·777
19	0·942	36	0·849	53	0·773
20	0·936	37	0·844	54	0·768
21	0·930	38	0·839	55	0·764
22	0·924	39	0·834	56	0·760
23	0·918	40	0·830	57	0·757
24	0·913	41	0·825	58	0·753
25	0·907	42	0·820	59	0·749
26	0·901	43	0·816	60	0·745

Spent Oxide of Iron.

The oxide of iron used in gas purification may be considered as "spent" when the quantity of free sulphur contained in it ranges between 45 and 55 per cent. by weight of the whole bulk of the material.

Although by continuing to use it the proportion of sulphur could be increased, it is not economical to do this beyond a certain point, as the purifiers would have to be changed more frequently, and the labour required for that purpose would be out of proportion to the benefit derived.

In addition to the sulphur, the spent oxide usually contains a small percentage of salts of ammonia, and some insoluble cyanides of iron, which are of value.

The spent oxide is generally sold at per unit of contained sulphur.

Mr. Andrew Stephenson has devised a handy apparatus (Fig. 111), for estimating the amount of sulphur in the oxide, and gives the following instructions for using the same:—

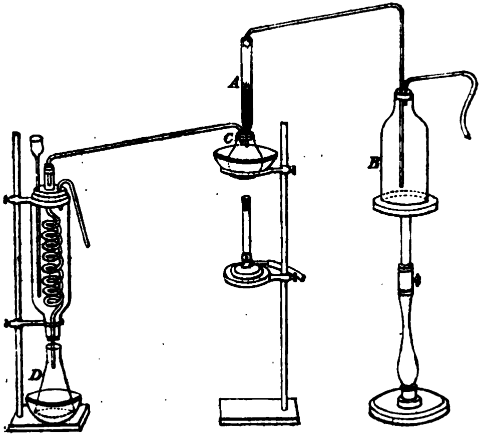


Fig. 111.

Weigh 100 grains of spent oxide, dry at 212° Fahr., and weigh to ascertain moisture; put the dried material in the test-tube, A, which is provided at the bottom with a filter of cotton wool.

Bisulphide of carbon is then blown from the holder, B, into the test-tube, A, on top of the spent oxide. It percolates the mass gradually and dissolves out the sulphur, the solution finding its way by gravitation into the flask, C, which is placed in a water-bath.

The Bunsen burner is then lighted, and the application of heat soon vaporizes the bisulphide of carbon from the flask, C. The vapour finds its way through the connecting-tube into the condenser, and is recovered in the receiver, D, under water, ready for further use.

The sulphur is left in the flask (the weight of which has been previously noted), and when all the bisulphide of carbon is driven off, the quantity of sulphur may be ascertained.

Fit the filter in the test-tube with care. If too tight, it will prevent filtration; if too loose, it will permit some of the oxide to pass through.

Three or four times the bulk of the oxide is about the proportion of bisulphide of carbon necessary to dissolve out all the sulphur.

It must always be borne in mind that bisulphide of carbon is very inflammable, and in the gaseous state when mixed with air in certain proportions it is explosive.

It is best to melt the sulphur in the flask before weighing, to drive off all bisulphide of carbon.

Gas Lime:

Its Composition, and Use in Agriculture.

In a valuable paper on gas lime, published in the *Journal of Gas Lighting,** Professor Voelcker states that a copious supply of air is necessary to transform the injurious sulphur compounds contained in the material into fertilizing agents.

When exposed to the air (and the longer it is kept exposed the better), gas lime is in some respects superior to quicklime as a manure.

The oxygen of the atmosphere destroys the offensive smell, and changes the sulphuret of calcium in it—first into sulphite, and finally into sulphate of lime or gypsum, well known as a valuable fertilizing substance.

In addition to its chemical virtues, gas lime exercises a beneficial *mechanical* effect upon land, by rendering stiff, heavy, clayey land more porous and friable, and by consolidating light sandy soils.

The crops which are particularly benefited by gas lime are—clover, sainfoin, lucerne, peas, beans, vetches, and turnips. It is a useful fertilizer, for permanent pasture, destroying the coarser grasses, and favouring the growth of a sweeter and more nutritious herbage.

It kills moss, heath, feather grass, and other plants characteristic of peaty land, its application to which cannot be too strongly recommended.

As a general rule, two tons per acre is the quantity of gas lime which ought to be put on land.

The proper time for its application is in autumn or winter.

During the period of storage, the heap should be turned over once or twice to ensure its complete exposure to the air.

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* Vol. xiv., p. 210.

The following is an analysis by Professor Voelcker of a sample of gas lime, *kept long enough to be used with safety as a manure*:—

Composition of Gas Lime (Dried at 212° *Fahr.).*

	Per Cent.
Water of combination and a little organic matter	**7·24**
Oxides of iron and alumina, with traces of phosphoric acid	**2·49**
Sulphate of lime (gypsum)	**4·64**
Sulphite of lime	**15·19**
Carbonate of lime	**49·40**
Caustic lime	**18·23**
Magnesia and alkalies	**2·53**
Insoluble siliceous matter	**0·28**
	100·00

In fresh gas lime the proportion of water varies usually from 30 to 40 per cent.

TABLE

Showing the Results Obtained by the Application of Certain Manures to Land. (Mr. Wilson, of Largs.)

Manure.	Produce of the Lot in lbs.	Pounds of Hay per Acre.	Increase per Acre over that Untouched.
Left untouched	**420**	**3360**	—
2½ barrels of quicklime	**602**	**4816**	**1456**
1 ton of lime from gas works	**651**	**5208**	**1848**
4½ cwt. of wood charcoal powder	**665**	**5320**	**1960**
2 bushels of bone dust	**693**	**5544**	**2184**
18 lbs. of nitrate of potash	**742**	**5936**	**2576**
20 lbs. of nitrate of soda	**784**	**6272**	**2912**
10 bushels of soot	**819**	**6552**	**3192**
28 lbs. of sulphate of ammonia	**874**	**6776**	**3416**
100 gals. of ammoniacal liquor from gas-works	**945**	**7562**	**4202**

The land was a piece of three years' old pasture, of uniform quality, divided into ten lots of 20 perches each. All the lots were manured at the same time with the articles given in the table, and the grass cut and made into hay in July. Each application cost the same.

Ammoniacal liquor is best applied at the following strength:—

Ammoniacal liquor	1 part.
Water	7 parts.

The proper time for its application is in the spring, after the grass has commenced growing, and during cloudy weather. It may be sprinkled on the land as water is applied to the streets of towns to lay the dust.

COAL PRODUCTS.

Table of the Principal Substances Obtained in the Manufacture of Coal Gas, and in the Utilization of the Residual Products arising therefrom.

Name of Product.	Formula or Symbol.	Reaction.	Specific Gravity. Water = 1.	Boiling Point. Degrees Fahrenheit.	
Acetic Acid	$C_4 H_4 O_4$	Acid	1·062	248°	Contained in coal tar.
Acetylene, or Klumine . .	$C_2 H_2$	Neutral	·898 (air = 1)	..	1 vol. C. vapour, 1 H. One of the hydrocarbons in coal gas, but in very small proportion. Its own bulk absorbed by water. This hydrocarbon in combination with copper produces a compound of a highly explosive nature, giving rise to obstructions in copper pipes, and in the attempt to remove which, dangerous accidents have occurred.
Alizarine (Lazaric Acid) . .	$C_{14} H_8 O_4$	Acid	..	..	The colouring principle of the madder root. Derived from anthracene by the addition of 4 atoms of O, and the abstraction of 2 atoms of H.
Alliaceous Oils	..	Neutral	..	..	Contained in coal tar.
Alum (Ammonia-Alum) . .	$Al_2(NH_4)_2 4 SO_4 + 24 H_2O$		..	..	Obtained by adding a solution of sulphate of ammonia to one of sulphate of alumina.
Ammonia	NH_3	Alkaline	·59 (air = 1)	27°	1½ vol. H, 1 vol. N. Exists in coal gas both in a free state and in combination. Attacks copper and brass fittings, and in burning with the gas forms nitric acid. Water at common temperatures absorbs 788 times its volume of the gas, its removal is therefore easily effected. Test, moistened turmeric paper.
Ammoniacal Liquor . . .	..	Alkaline	..	..	The aqueous portion of the condensed coal products, being a solution, chiefly of carbonate, sulphide, and sulphocyanide of ammonium. Average yield of coal, 25 gals. per ton of 8 oz. liquor, equal to 4° Twaddel.

Name of Product.	Formula or Symbol.	Reaction.	Specific Gravity. Water = 1.	Boiling Point. Degrees Fahrenheit.	
Amyl	$C_{10} H_{11}$	Neutral	4·9 (air = 1)	..	5 vols. C, 11 vols. H. A constituent (hydrocarbon) of coal gas. Belongs to the alcohol radical series of hydrocarbons.
Amylene	$C_5 H_{10}$	Neutral	2·4 (air = 1)	As a liquid 102°	2½ vols. C, 5 vols. H. One of the hydrocarbons in coal gas, of the olefiant gas series. It is also a constituent of coal tar.
Amylhydride	$C_5 H_{12}$	Neutral	2·49 (air = 1)	..	2½ vols. C, 6 vols. H. Of the marsh gas series of hydrocarbons.
Aniline	$C_6 H_7 N$	Alkaline	1·060	360°	The base of all the dyes bearing this name, and is obtained by the action of nascent hydrogen on nitro-benzole.
Anthracene	$C_{14} H_{10}$	Neutral	1·147	680°	Contained in the least volatile portion of the coal oils. The colouring principle of madder, alizarine, is derived from this substance.
Anthraquinone	$C_{14} H_8 O_2$	Acid	..	..	Derived from anthracene.
Aqueous Vapour	$H_2 O$	Neutral	·622 (air = 1)	..	A constituent of raw gas, and removed, though not entirely, by condensation.
Benzylic Hydride, see Toluole.					
Benzole, Benzine, or Phene	$C_6 H_6$	Neutral	·850	176°	Remarkable for its solvent power for caoutchouc, gutta-percha, resins, and fats. Used also for preparing varnishes, for removing grease spots, and cleansing soiled white kid gloves. It is the chief constituent of naphtha, and, treated with nitric acid, yields nitro-benzole, from which analine is derived.
Benzole Vapour, or Bicarburetted Hydrogen.	$C_6 H_6$	Neutral	2·7 (air = 1)	..	3 vols. C, 3 vols. H. One of the hydrocarbons existing in coal gas. Slightly absorbed by water; easily condensed by cold. Like the other richer hydrocarbons, it is absorbed by vulcanized india-rubber tubing.
Bicarburetted Hydrogen, see Benzole Vapour.					

Name of Product.	Formula or Symbol.	Reaction.	Specific Gravity. Water = 1.	Boiling Point. Degrees Fahrenheit.	
Bisulphide of Carbon . . .	CS_2	Acid	2·64 (air = 1)	The liquid 117°	One of the impurities in coal gas; and, until recently, the most difficult to eliminate. Not condensed by cold; not soluble in water. Removable by sulphide of calcium (foul lime) in the purifiers.
Bisulphuret of Carbon, see Bisulphide of Carbon.					
Brunolic Acid.	..	Acid	..	..	Contained in coal tar.
Butyl	C_8H_9	Neutral	3·94 (air = 1)	..	4 vols. C, 9 vols. H. A hydrocarbon existing in coal gas, and belonging to the alcohol radical series.
Butylene, Tetryline, Ditetryl, or Oil Gas.	C_4H_8	Neutral	1·94 (air = 1)	..	2 vols. C, 4 vols. H. A hydrocarbon found in coal gas, and of the olefiant gas series. It is also a constituent of coal tar.
Butyl-hydride.	C_4H_{10}	Neutral	Gas 2· (air = 1) Liquid ·600	..	2 vols. C, 5 vols. H. A hydrocarbon existing in coal gas, and belonging to the marsh gas series. It exists also as a colourless liquid, and is the lightest of all known liquids, its specific gravity being only ·600.
Butyric Acid	$C_8H_8O_4$	Acid	·973	314°	One of the acids of coal tar.
Caproylene, see Hexylene.					
Carbolic Acid; Phenic Acid or Phenol.	C_6H_6O	Acid	1·065	370°	Contains valuable antiseptic and disinfecting properties, and is used for making dyes. It is obtained from coal tar.
Carbon	C	..	..	..	This element is the basis of the illuminating qualities of coal gas. In the flame of hydrogen its particles are heated to incandescence, and emit intense light. Afterwards uniting with the oxygen of the atmosphere to form carbonic acid, one of the products of the combustion of coal gas. The solid deposit upon the interior surface of gas retorts is almost pure carbon, and is used in the construction of the Bunsen galvanic battery, and for the carbon points or candles producing the Arc electric light.

Name of Product.	Formula or Symbol.	Reaction.	Specific Gravity. Water = 1.	Boiling Point. Degrees Fahrenheit.	
Carbonate of Ammonia . .	$(2\ NH_3, 3\ CO_2 + 2\ HO)$		..	..	A salt produced by the chemical combination of ammonia with carbonic acid gas. When exposed to the atmosphere it gradually attracts more carbonic acid from the air, and becomes bicarbonate of ammonia, which is used by bakers, instead of yeast, in preparing light and spongy cakes.
Carbonic Acid, called also Black Damp.	CO_2	Acid	1·52 (air = 1)	..	½ vol. C vapour, 1 vol. O. The presence of this impurity in common coal gas to the extent of only 1 per cent. will diminish the light about 5 per cent. Soluble in its own volume of water. Is entirely removed from gas by the use of lime. Test, lime water.
Carbonic Oxide	CO	..	·967 (air = 1)	..	½ vol. C vapour, ½ vol. of O. Exists in coal gas in small proportion. 100 vols. water absorb about 2·48. Test, an ammoniacal solution of subchloride of copper.
Cespitine	$C_{10}\ H_{13}\ N$	Alkaline	..	205°	A constituent of coal tar.
Chinoline	$C_{18}\ H_7\ N$	Alkaline	1·081	462°	Do. do.
Chrysene	$C_{12}\ H_4$	Neutral	..	..	Do. do.
Coke.	..	..	..	..	The valuable product obtained in the manufacture of coal gas. Consists mainly of carbon.
Collidine	$C_8\ H_{11}\ N$	Alkaline	·987	354°	A constituent of coal tar, contained in the light oil.
Condensable Hydrocarbons .	..	..	..	..	Includes all the hydrocarbons existing in coal tar. But indeed the whole of the more volatile hydrocarbons existing in coal gas are liable to be condensed by extreme cold, hence the importance of preventing the gas from being subjected to a temperature below 50° Fahr.
Coridine	$C_{20}\ H_{15}\ N$	Alkaline	..	412°	A constituent of coal tar.

Name of Product.	Formula or Symbol.	Reaction.	Specific Gravity. Water = 1.	Boiling Point. Degrees Fahrenheit.	
Creosote, or Dead Oil	..	..	..	..	Obtained in large quantity in the distillation of coal tar. Used in the preservation of timber, such as railway sleepers, &c. It is also useful as a fuel, and, in combination with caustic soda and tallow, as a dip for washing sheep.
Cresylic Acid, or Cresol	$C_{14} H_8 O_2$	Acid	..	397°	One of the coal tar acids.
Crude Naphtha	..	Neutral	..	..	The first naphtha obtained in the distillation of coal tar, and which comes over at a temperature from 180° to 310° Fahr.
Cryptidine	$C_{22} H_{11} N$	Alkaline	..	525°	One of the coal tar alkalies.
Cumene	$C_9 H_{12}$	..	..	381°	A constituent of coal tar, obtained from the light oil.
Cumidine	$C_{18} H_{13} N$	Alkaline	·952	437°	One of the coal tar alkalies.
Cumole	$C_9 H_{12}$	Neutral	Liquid ·870 Gas 4·15 (air = 1)	302°	A constituent both of coal gas and tar, of the benzole series of hydrocarbons. 4½ vols. C, 6 vols. H.
Cyanogen	$C_2 N$	..	1·8 (air = 1)	..	1 vol. N, 1 vol. C. Produced during the destructive distillation of coal, but, with the exception of a very small proportion which passes into the gas, is condensed and carried into the tar well along with the ammoniacal liquor. Not readily absorbed by water; but by alkalies and alkaline sulphides. Combined with iron it forms Prussian blue, and is the cause of the bluish-green colour in spent lime. In union with ammonium sulphide, it forms sulpho-cyanide of ammonium, a substance used by photographers, and in the preparation of the constituent of the toys known as "Pharaoh's Serpents." It is a highly poisonous gas.
Cymidine	$C_{20} H_{15} N$	Alkaline	..	482°	An alkaline body contained in coal tar.

Name of Product.	Formula or Symbol.	Reaction.	Specific Gravity. Water = 1.	Boiling Point. Degrees Fahrenheit.	
Cymole or Cymene	$C_{10} H_{14}$	Neutral	Liquid ·861 Gas 4·68 (air = 1)	349°	A constituent both of coal gas and tar; of the benzole series of hydrocarbons. 5 vols. C, 7 vols. H.
Dead Oil, see Creosote.					
Decyl	$C_{20} H_{21}$	Neutral	..	..	Constituent of coal tar.
Decylene	$C_{20} H_{20}$	Neutral	..	..	Do. do.
Decyl-hydride	$C_{20} H_{22}$	Neutral	..	..	Do. do.
Dispoline	$C_{11} H_{11} N$	..	..	..	A constituent of coal tar, obtained from the heavy oil.
Disulphide of Carbon, see Bisulphide of Carbon.					
Ditetryl, see Butylene.					
Elayl, see Olefiant Gas.					
Ethyl	$C_4 H_5$	Neutral	2· (air = 1)	..	A constituent of coal gas. 2 vols. C, 5 vols. H. 2·15 vols. soluble in 100 vols. water.
Ethylamine	$C_4 H_7 N$	Alkaline	..	66°	A constituent of coal tar.
Ethylene, see Olefiant Gas.					
Ethyl-hydride	$C_4 H_6$	Neutral	1·04 (air = 1)	..	A constituent of coal gas. 1 vol. C, 3 vols. H; of the marsh gas series of hydrocarbons.
Ettidine	$C_{15} H_{10} N$	..	..	..	A constituent of coal tar, obtained from the heavy oil.
Eupion	..	..	..	..	Obtained from coal tar, and proposed to be used as a substitute for chloroform.
Fire-damp, see Light Carburetted Hydrogen.					
Green Oil	..	..	..	..	This follows the dead oil in the distillation of coal tar, and, mixed with resin and oil, is used for making railway grease. Lamp black, from which printers' ink is prepared, is also made from it.
Heptylene, see Œnanthylene.					

Name of Product.	Formula or Symbol.	Reaction.	Specific Gravity. Water = 1.	Boiling Point. Degrees Fahrenheit.	
Hexyl	$C_6 H_{13}$	Neutral	. .	. .	A constituent of coal gas.
Hexylene, or Caproylene . .	$C_6 H_{12}$	Neutral	. .	160°	A constituent of coal tar, contained in the light oil.
Hexyl-hydride	$C_6 H_{14}$	Neutral	. .	154°	A constituent of coal gas.
Hydric sulphide, see Sulphuretted Hydrogen.					
Hydride of Amyl, see Amyl-hydride.					
Hydride of Butyl, see Butyl-hydride.					
Hydride of Decyl, see Decyl-hydride.					
Hydride of Ethyl, see Ethyl-hydride.					
Hydride of Hexyl, see Hexyl-hydride.					
Hydride of Methyl, see Methyl-hydride, or Light Carburetted Hydrogen.					
Hydride of Octyl, see Octyl-hydride.					
Hydride of Phenyl, see Benzole					
Hydride of Propyl, see Propyl-hydride.					
Hydrocarbons.	. .	. .	. .	. .	The different compounds of carbon and hydrogen, gaseous or volatile and condensable, contained in illuminating gas and in coal tar, constituting the light-giving material of the former and the rich and valuable products of the latter.

Name of Product.	Formula or Symbol.	Reaction.	Specific Gravity. Water = 1.	Boiling Point. Degrees Fahrenheit.	
Hydrocyanic Acid	HCN	Acid	..	..	Obtained from coal tar.
Hydrogen	H	..	·0691 (air = 1)	..	The lightest known substance in nature. 100 vols. water absorb 1·93. One of the chief constituents of coal gas, in which it exists to the extent of 12 to 50 per cent. Pure hydrogen gives scarcely any light during combustion, but when solid substances are suspended in the flame, which has the high temperature of 5898° Fahr., considerable light is emitted.
Hydrosulphocyanic Acid . .	S (CN) H	Acid	..	..	Obtained from coal tar.
Hydrosulphuric Acid, see Sulphuretted Hydrogen.					
Isoline	$C_{14} H_{17} N$	..	..	..	A constituent of coal tar, obtained from the heavy oil.
Klumine, see Acetyline.					
Leucoline, or Quinoline . .	$C_{18} H_7 N$	Alkaline	..	455°	Obtained from coal tar.
Lepidine	$C_{10} H_9 N$	Alkaline	1·072	510°	Do. do., obtained from the heavy oil.
Light Carburetted Hydrogen, also named Marsh Gas, Pit Gas, Fire Damp, and Hydride of Methyl.	$C H_4$	Neutral	·56 (air = 1)	..	A constituent of coal gas to the extent of 30 to 60 per cent. ½ vol. C vapour, 2 vols. H. Not condensed by cold, and not easily decomposed by heat. 100 vols. water absorb 3·91 vols.
Light Oil	..	..	..	..	The oil that follows the crude naphtha, and precedes the creosote or dead oil in the destructive distillation of coal tar. It is usually redistilled along with the crude naphtha for obtaining benzole. The two are also used for making black varnish, or for burning in the common naphtha lamp.
Liquid Ammonia	..	Alkaline	·880	..	A solution of ammonia gas in water.
Lutidine	$C_7 H_9 N$	Alkaline	·946	309°	A constituent of coal tar, contained in the light oil.
Marsh Gas, see Light Carburetted Hydrogen.					

Name of Product.	Formula or Symbol.	Reaction.	Specific Gravity. Water = 1.	Boiling Point. Degrees Fahrenheit.	
Mesitylene.	$C_9 H_{12}$	..	..	325°	A constituent of coal tar, obtained from the light oil.
Methyl	$C_2 H_3$	Neutral	1·04 (air = 1)	..	1 vol. C, 3 vols. H. 100 vols. water absorb 5·08 vols. A constituent of coal gas, of the alcohol radical series of hydrocarbons.
Methylamine	$C_2 H_5 N$	Alkaline	..	..	Obtained from coal tar.
Methylene.	$C H_2$	Neutral	·484 (air = 1)	..	A constituent of coal gas, of the olefiant gas series of hydrocarbons. ½ vol. C, 1 vol. H. Not soluble in water.
Methyl - hydride, see Light Carburetted Hydrogen.					
Mirbane, Essence of, see Nitro-benzole.					
Muriate of Ammonia, or (when sublimated) Sal Ammoniac.	$NH_3 HCl$ or $NH_4 Cl$	Alkaline	..	..	The important salt which is produced from ammoniacal liquor when the latter is saturated with muriatic or hydrochloric acid. Nearly all the medicinal preparations of ammonia are obtained from this salt. Used also in fixing the colours in woollen.
Naphtha, see Crude Naphtha.					
Naphthaline	$C_{10} H_8$	Neutral	1·153	414°	5 vols. C, 4 vols. H. A constituent of coal tar.
Naphthaline Vapour . . .	$C_{10} H_8$	Neutral	4·42 (air = 1)	..	5 vols. C, 4 vols. H. Not soluble in water, but by naphtha and coal tar. Quickly deposited by cold.
Naphthylamine	$C_{10} H_9 N$	Neutral	..	..	A compound produced from naphthaline.
Nitric Acid	HNO_3	Acid	1·51	Not constant	A small proportion of this acid is formed when nitrogen is burnt with coal gas.
Nitro-benzol, Nitrobenzine, or Essence of Mirbane.	$C_6 H_5 NO_2$	Neutral	..	..	The substance produced by the action of fuming nitric acid on benzole naphtha, and which is used for the manufacture of aniline

	Symbol.	Reaction.	Water = 1.	Degrees Fahrenheit.	
Nitrogen	N	..	·9718 (air = 1)	..	100 vols. water absorb 1·48 vol. The presence of nitrogen in coal gas is sometimes due to irregularity in the working of the exhauster, by which a vacuum is created, and air drawn in through the fissures of the retorts. The nitrogen contained in the coal, and which is eliminated by distillation, is evolved in combination with hydrogen as ammonia. Its effect is to injure the illuminating power.
Octyl	$C_8 H_{17}$	Neutral	..	..	A constituent of coal gas.
Octylene	$C_8 H_{16}$	Neutral	..	..	Do. do.
Octyl-hydride	$C_8 H_{18}$	Neutral	..	246	Do. do. contained in the light oil.
Œnanthylene	$C_7 H_{14}$	Neutral	..	210	Obtained from coal tar, from the light oil.
Olefiant Gas, Ethyline, or Elayl.	$C_2 H_4$	Neutral	·968 (air = 1)	..	1 vol. C, 2 vols. H; 100 vols. water absorb 16. Condensable by cold and great pressure. Exists in coal gas in proportions varying from 8 to 27 per cent., and contributes greatly to its illuminating power. It contains twice as much carbon as light carburetted hydrogen. Test, brown or fuming sulphuric acid.
Oxygen	O	..	1· 1)	..	2·99 vols. absorbed by 100 vols. water. The presence of oxygen in coal gas is due (like nitrogen) to the drawing in of air through the retorts and apparatus by too rapid working of the exhauster, and also to the opening of the retorts and purifiers for charging and discharging. 2 per cent. of air injures the illuminating power of the gas to the extent of 10 per cent.; 7 per cent. of air diminishes the light one-half, whilst about 25 per cent. of air practically destroys it.

Name of Product.	Formula or Symbol.	Reaction.	Specific Gravity. Water = 1.	Boiling Point. Degrees Fahrenheit.	
Paraffin.	$C_{17}H_{36}$ to $C_{27}H_{56}$	Neutral	·870	..	A colourless, solid, crystalline, fatty substance, chiefly obtained from the tar from Boghead cannel. It is manufactured into candles, giving a brilliant white light; and oil of high lubricating properties is made from it. Paraffin oil will only burn in the presence of a wick, and is therefore perfectly safe.
Paranaphthaline, see Anthracene.					
Parvoline	$C_9H_{13}N$	Alkaline	..	370°	A constituent of coal tar, contained in the light oil.
Pentahiroline	$C_{13}H_{15}N$	..	..	..	A constituent of coal tar, obtained from the heavy oil.
Pentylene	C_5H_{10}	..	..	88°	A constituent of coal tar, contained in the light oil.
Petinine	..	Alkaline	..	176°	A constituent of coal tar.
Phenic Acid, see Carbolic Acid					
Phlorylic Acid, or Phlorol. .	$C_{16}H_{10}O_2$	Acid	..	424°	Do. do.
Picoline.	C_6H_7N	Alkaline	·961	278°	Do. do. contained in the light oil.
Pit Gas, see Light Carburetted Hydrogen.					
Pittacal.	..	..	..	..	Found in the heaviest portions of the coal tar oil
Pitch	..	..	..	..	The residue remaining of the distillation of coal tar, of which it constitutes about 66 per cent. by weight. It is extensively used for asphalting.
Propyl	C_6H_7	Neutral	2·97 (air = 1)	..	A constituent of coal gas, of the alcohol radical series of hydrocarbons. 3 vols. C, 7 vols. H. Not soluble in water.
Propylene, or Tritylene . .	C_3H_6	Neutral	1·455 (air = 1)	..	A constituent both of coal gas and coal tar. Condensed by cold and pressure. Of the olefiant gas series of hydrocarbons. 1½ vol. C, 3 vols. H.
Propy-hydride	C_3H_8	Neutral	1·522 (air = 1)	..	A constituent of coal gas, of the marsh gas series of hydrocarbons. 1½ vol. C, 4 vols. H.

Name of Product.	Formula or Symbol.	Reaction.	Specific Gravity. Water = 1.	Boiling Point. Degrees Fahrenheit.	
Pyrene	$C_{30}H_4$	Neutral	..	..	A constituent of coal tar. White crystalline body.
Pyridine, see Pyrrhidine.					
Pyrrhidine	C_5H_5N	Alkaline	·986	248°	A constituent of coal tar, contained in the light oil.
Pyrrol	C_4H_5N	Alkaline	1·077	271°	A constituent of coal tar, contained in the light oil.
Quinoline, see Leucoline.					
Rosalic Acid	$C_{24}H_{12}O_6$	Acid	..	..	Do. do.
Rubidine	$C_{22}H_{17}N$	Alkaline	..	446°	Do. do.
Sal Ammoniac, see Muriate of Ammonia.					
Spent Lime, see also Sulphide of Calcium.	..	..	..	..	The foul lime of the purifiers. Used as a manure or top dressing for land.
Spent Oxide of Iron. . . .	..	..	..	..	The hydrated peroxide of iron, employed in abstracting the sulphuretted hydrogen from the gas having become charged with free sulphur to the extent of 40 to 75 per cent. by a succession of foulings and revivifications, is used by the manufacturing chemists for making sulphuric acid.
Sulphate of Ammonia . . .	$2(NH_4)SO_4$	..	..	..	The valuable salt produced by the neutralization of the ammonia from ammoniacal liquor with sulphuric acid. Largely used as a manure, and, by the addition of a solution of sulphate of alumina, in the manufacture of ammonia alum.
Sulphide of Calcium, or Spent Lime.	..	..	..	..	The "fouled" lime of the purifiers, and which is efficacious in absorbing from the gas the bisulphide of carbon impurity, and the sulphur compounds other than sulphuretted hydrogen.
Sulphide of Carbon, see Bisulphide of Carbon.					

Name of Product.	Formula or Symbol.	Reaction.	Specific Gravity. Water = 1.	Boiling Point. Degrees Fahrenheit.	
Sulphocyanogen	..	..	..	..	A constituent of raw gas.
Sulpho-hydrocarbons . . .	.	..	..	..	Surphur impurities exisiting in coal gas.
Sulphur.	S	..	..	570°	In the best gas-producing coals the amount of sulphur present rarely exceeds 1½ per cent., generally it is much less. In the process of distillation about one-half the contained sulphur remains in the residual coke, whilst the other half is volatilized, and, combining with H and C, constitutes impurities requiring removal.
Sulphuret of Carbon, see Bisulphide of Carbon.					
Sulphuretted Hydrogen . .	H_2S	Acid	1·1747 (air = 1)	..	The chief impurity in raw or crude coal gas. It is entirely removed by the use of lime or oxide of iron. It is an inflammable gas, and generates sulphurous acid in burning. 1 vol. of water at 60° absorbs 3·23 vols. of the gas. Test, acetate of lead or nitrate of silver in solution.
Sulphuric Acid	H_2SO_4	Acid	1·845	388°	This, which is the most important and useful of all the acids, is largely manufactured from the sulphur contained in the spent oxide of iron, after having been used in the purification of coal gas from sulphuretted hydrogen.
Sulphurous Acid.	SO_2	Acid	2·247 (air = 1)	..	This gas is produced when sulphur and its compounds are burnt. Hence, illuminating gas containing sulphur yields it during combustion. The quantity given out, however, even with the most impure gas (say with 40 grains sulphur in the 100 feet), is so inappreciable as to be perfectly innocuous in its effects, especially where the smallest attention is paid to ventilation.

Name of Product.	Formula or Symbol.	Reaction.	Specific Gravity. Water = 1.	Boiling Point. Degrees Fahrenheit.	
Tar	..	..	Ordinary Coal Tar, 1·120 to 1·150 Cannel Coal Tar ·980 to 1·060	..	The well-known complex, viscid liquid, produced in the destructive distillation of coal, and from which a great variety of valuable products is obtained. It consists almost entirely of hydrocarbon compounds, with a varying proportion of solid carbon. Tar, on distillation, yields on the average— 2·4 per cent. ammoniacal liquor 1·6 „ crude naphtha 1·2 „ light oil 28·8 „ creosote or dead oil 66·0 „ pitch 100·0
Tetrahiroline	$C_{12} H_{13} N$	..	..	..	A constituent of coal tar, obtained from the heavy oil.
Tetrylene, see Butylene.					
Toluidine	$C_7 H_9 N$	Alkaline	..	388°	A constituent of coal tar.
Toluole	$C_7 H_8$	Neutral	Liquid ·870 Gas 3·179 (air = 1)	232°	A constituent both of coal gas and tar. Of the benzole series of hydrocarbons. 3½ vols. C, 4 vols. H. Not soluble in water.
Tritylene, see Propylene.					
Validine	$C_{16} H_{21} N$	..	..	..	A constituent of coal tar, obtained from the heavy oil.
Viridine.	$C_{24} H_{19} N$	Alkaline	..	484°	A constituent of coal tar.
Water	$H_2 O$	Neutral	1·000	212°	Produced as aqueous vapours, in more or less proportion, during the distillation of coal. It is also one of the products of the combustion of coal gas, from the union of the hydrogen of the gas with the oxygen of the air.
Xylene	$C_8 H_{10}$	..	..	282°	The base of xylidine, obtained from the light oil. Used in the preparation of scarlet dyes.
Xylidine	$C_{16} H_{11} N$	Alkaline	..	415°	A constituent of coal tar.
Xylole	$C_8 H_{10}$	Neutral	Liquid ·867 Gas 3·662 (air = 1)	259°	A constituent both of coal gas and tar. Of the benzole series of hydrocarbons. 4 vols. C, 5 vols. H. Not soluble in water.

CHEMICAL AND OTHER MEMORANDA.

The compounds of the non-metallic elements with the metals and with each other have names ending in "ide" or "uret;" as $Fe\ S$, sulphide or sulphuret of iron.

When two or more atoms or equivalents of the non-metallic elements enter into combination, the number of atoms or equivalents is expressed by prefixes.

Mon . . .	means 1 atom, as $N_2\ O$, nitrogen mon-oxide.
Di, bin, or bi	means 2 atoms, as $N_2\ O_2$, nitrogen di-oxide, or bin-oxide of nitrogen: CS_2, bi-sulphide or di-sulphide of carbon.
Tri or ter. .	means 3 atoms, as $N_2\ O_3$, nitrogen tri-oxide; $Sb_2\ S_3$, ter-sulphide of antimony
Tetr . . .	means 4 atoms, as $N_2\ O_4$, nitrogen tetr-oxide.
Pent or penta	means 5 atoms, as $N_2\ O_5$, nitrogen pent-oxide; PCl_5, penta-chloride of phosphorus.
Sesqui. . .	means 1½ atoms (= 2 to 3), as $Fe_2\ O_3$, sesqui-oxide of iron.
Proto or prot	means first, as $Fe\ O$, prot-oxide of iron.
Sub . . .	means under, as $Cu_2\ O$, sub-oxide of copper.
Per . . .	means the highest, as $H\ Cl\ O_4$, per-chloric acid.

The termination "ic" and "ous" are used for acids, the former representing a higher state of oxidation than the latter.

When a substance forms more than two acid compounds, the prefixes "hypo," *under*, and "hyper," *above*, are used.

The small number, as H_2, placed to the right of, and slightly below a symbol is called the exponent, and indicates the number of times that the combining weight of the substance has to be taken. When the symbol is without a number—thus, H—the number *one* is understood. The small numbers modify only the symbol immediately preceding, but larger numbers *prefixed* to the symbol modify all that follow as far as the next comma or + sign: thus $2H_2\ SO_4$ signifies that four of hydrogen, two of sulphur, and eight of oxygen, or, more correctly, that two of sulphuric acid ($H_2\ SO_4$ being the formula for sulphuric acid) are to be taken.

A base is a compound which will chemically combine with an acid.

A salt is a compound of an acid and a base.

When water is in combination with acids or bases, they are said to be hydrated.

Alkalies neutralize acids, forming salts.

Alkalies turn vegetable reds to blue, and yellows to brown.

Acids turn vegetable blues to red, and browns to yellow.

A *simple* or *elementary* substance is a body that cannot be resolved or separated into any simpler substances—as oxygen, carbon, iron.

A *compound* substance is one consisting of two or more constituents —as water, carbonic acid gas, olefiant gas.

The equivalent number or atomic or combining weight expresses the relation that subsists between the different proportions by weight in which substances unite chemically with each other.

The equivalent or combining weight of a compound is the sum of the combining weights of its constituents.

Specific gravity expresses the difference that subsists between the weights of equal volumes of bodies. Gases are usually compared with air as 1·000, liquids and solids with water as 1·000.

So far as chemists have been able to discover, there are about 65 elementary or simple substances.

No compound body contains all the elementary substances. Most *compounds* are composed of two, three, or four elements.

TABLE OF ELEMENTARY SUBSTANCES.

ames of Elements.	Symbols.	Atomic or Combining Weights.	Names of Elements.	Symbols.	Atomic or Combining Weights.
uminum . . .	Al	27·4	Molybdenum . .	Mo	96
timony (Stibium)	Sb	122	Nickel.	Ni	58·7
enic	As	75	Niobium	Nb	94
rium	Ba	137	Nitrogen	N	14
muth	Bi	210	Osmium	Os	199·2
ron	B	11	Oxygen	O	16
omine	Br	80	Palladium . . .	Pd	106·6
dmium. . . .	Cd	112	Phosphorus . . .	P	31
sium	Cs	133	Platinum	Pt	197·5
lcium	Ca	40	Potassium (Kalium)	K	39·1
rbon	C	12	Rhodium	Rh	104·4
rium	Ce	92	Rubidium . . .	Rb	85·4
lorine	Cl	35·5	Ruthenium . . .	Ru	104·4
romium . . .	Cr	52·2	Selenium	Se	79·5
alt	Co	58·7	Silicium or Silicon .	Si	28
pper (Cuprum) .	Cu	63·5	Silver (Argentum) .	Ag	108
ymium . . .	D	95	Sodium (Natrium) .	Na	23
ium	E	112·6	Strontium . . .	Sr	87·5
orine	F	19	Sulphur	S	32
cinum or Beryl- um	Gl	9·3	Tantalum or Columbium	Ta	182
ld (Aurum) . .	Au	197	Tellurium . . .	Te	128
drogen. . . .	H	1	Thallium.	Tl	204
ium	In	37·8	Thorium	Th	115·7
ine	I	127	Tin (Stannum) . .	Sn	118
ium	Ir	198	Titanium	Ti	50
n (Ferrum) . .	Fe	56	Tungsten (Wolfram)	W	184
nthanum . . .	La	92	Uranium	U	120
ad (Plumbum) .	Pb	207	Vanadium . . .	V	51·3
hium	Li	7	Yttrium	Y	61·6
gnesium . . .	Mg	24	Zinc	Zn	65·2
nganese . . .	Mn	55	Zirconium . . .	Zr	89·6
rcury (Hydrarg.)	Hg	200			

LIST OF SUBSTANCES,

mple and Compound, frequently Mentioned in Connection with the Manufacture and Purification of Coal Gas and the Residual Products resulting therefrom.

Name of Substance.	Symbol.
Ammonia	NH_3
Aniline	$C_{12}H_7N$
Aqueous vapour	H_2O
Benzole	C_6H_6
Bisulphide of carbon	CS_2
Bisulphide of iron	FeS_2
Butylene	C_4H_8
Carbon	C
Carbolic acid	$C_{12}H_6O_2$
Carbonate of ammonia.	$2NH_3\,3CO_2 + 2HO$
Carbonate of lime	$CaCO_3$
Carbonic acid	CO_2
Carbonic oxide.	CO
Cyanogen	CN
Hydrogen	H

LIST OF SUBSTANCES—*Continued.*

Name of Substance.	Symbol.
Hydrochloric or muriatic acid	HCl
Light carburetted hydrogen	CH_4
Muriate of ammonia	$NH_3 HCl$, or $NH_4 Cl$
Naphthaline	$C_{10} H_8$
Nitrogen	N
Nitric acid	HNO_3
Olefiant gas	$C_2 H_4$
Oxygen	O
Oxide of calcium (caustic lime)	$Ca O$
Oxide of potassium (caustic potash)	KO
Oxide of sodium (caustic soda)	$Na O$
Peroxide of iron	$Fe_2 O_3$
Protoxide of iron	$Fe O$
Protochloride of manganese	$Mn Cl$
Propylene	$C_3 H_6$
Sulphur	S
Sulphate of ammonia	$2 (NH_4) SO_4$
Sulphide of calcium	$Ca S$
Sulphide of iron	$Fe S$
Sulphuretted hydrogen	$H_2 S$
Sulphuric acid	$H_2 SO_4$
Sulphurous acid	SO_2
Water	$H_2 O$

To ascertain the proportion, by *weight*, of the different substances in a compound, multiply the atomic or combining weight of each substance by the exponent.

For example: Take olefiant gas, $C_2 H_4$, which, as its formula indicates, consists, by weight, of two atoms of carbon combined with four atoms of hydrogen—

	Atomic or Combining weight.		Exponent.		Proportion by weight.	
C	12	×	2	=	24	or 85·715 per cent.
H	1	×	4	=	4	or 14·285 ,,

So that, 24 grains, or 24 ounces, or 24 pounds of carbon, combine with 4 grains, or 4 ounces, or 4 pounds of hydrogen to form 28 grains, or 28 ounces, or 28 pounds, and so on, of olefiant gas.

COMMON NAMES OF CERTAIN CHEMICAL SUBSTANCES.

Aqua fortis	Nitric acid.
Aqua regia	A mixture of nitric and hydrochloric acids, so called from its property of dissolving gold.
Bluestone, or blue vitriol	Sulphate of copper.
Calomel	Chloride of mercury.
Chloroform	Chloride of formyle.
Common salt	Chloride of sodium.
Copperas, or green vitriol	Sulphate of iron.
Corrosive sublimate	Bichloride of mercury.
Dry alum	Sulphate of alumina and potash.
Epsom salts	Sulphate of magnesia.
Ethiops mineral	Black sulphide of mercury.
Fire-damp	Light carburetted hydrogen.
Galena	Sulphide of lead.

CHEMICAL SUBSTANCES—*Continued.*

Glauber's salts	Sulphate of soda.
Goulard water	Basic acetate of lead.
Iron pyrites	Bisulphide of iron.
Jeweller's putty	Oxide of tin.
King's yellow	Sulphide of arsenic.
Laughing gas	Protoxide of nitrogen.
Lime	Oxide of calcium.
Lunar caustic	Nitrate of silver.
Mosaic gold	Bisulphide of tin.
Muriate of lime	Chloride of calcium.
Nitre, or saltpetre	Nitrate of potash
Oil of vitriol	Sulphuric acid.
Potash	Oxide of potassium.
Realgar	Sulphide of arsenic.
Red lead	Oxide of lead.
Rust of iron	Oxide of iron.
Sal ammoniac	Muriate of ammonia.
Soda	Oxide of sodium.
Spirit of hartshorn	Ammonia.
Spirit of salt	Hydrochloric or muriatic acid.
Stucco, or plaster of Paris	Sulphate of lime.
Sugar of lead	Acetate of lead.
Tincal	Crude borax.
Verdigris	Basic acetate of copper.
Vermilion	Sulphide of mercury.
Vinegar	Acetic acid.
Volatile alkali	Ammonia.
Wad	Black oxide of manganese.
Water	Oxide of hydrogen.
White vitriol	Sulphate of zinc.

TABLE OF VARIOUS GASES.

Their Specific Gravity, Weight, and Solubility in Water.
60° Fahr. 30 in. Barometer.

Name.	Specific Gravity. Air equal 1·000.	Weight of a Cubic Foot in Pounds Avoirdupois.	Weight of a Cubic Foot in Grains.	Number of Cubic Ft. equal to 1 lb.	Solubility, 100 Vols. of Water absorb.
ydrogen	·0691	·00529997	37·09	188·68	1·93 Vols.
ight carburetted hydrogen	·559	·0428758	300·12	23·32	8·91 „
mmonia	·590	·045253	316·77	22·09	7830· „
arbonic oxide	·967	·0741689	519·18	13·48	2·43 „
lefiant gas	·968	·0742456	519·71	13·46	16· „
itrogen	·9713	·07449871	521·49	13·42	1·48 „
ir	1·000	·0767	536·90	13·08	
itric oxide	1·039	·0796913	557·83	12·54	Not soluble in water.
xygen	1·1056	·08479952	593·59	11·79	2·99 Vols.
ulphuretted hydrogen	1·1747	·09009949	630·69	11·09	323· „
itrous oxide	1·527	·1171209	819·84	8·53	100· „
arbonic acid	1·529	·1172743	820·92	8·52	100· „
ulphurous acid	2·247	·1723449	1206·41	5·80	4300· „
hlorine	2·470	·189449	1326·14	5·27	200· „
isulphide of carbon	2·640	·202488	1417·41	4·93	Not soluble in water.

To reduce a volume of gas of any specific gravity to pounds avoirdupois, multiply the volume by the sp. gr. and by ·0767.

Example.—Required the weight of 1500 cubic feet of gas whose specific gravity is ·520.

$$1500 \times \cdot520 \times \cdot0767 = 59\cdot826 \text{ lbs.}$$

To find the weight in pounds avoirdupois of a cubic foot of air at different temperatures, and under different pressures,

$$W = \frac{1\cdot3253 \times B}{459 + T}$$

Example.—Required the weight of a cubic foot of air, the barometer being at 29·5 inches, and the temperature 84° Fahr.

$$\frac{1\cdot3253 \times 29\cdot5}{459 + 84} = \cdot072 \text{ lb.}$$

WATER.

1 pint = 34·65 cubic inches, or 1·25 lbs.
1 gal. = 277·274 cubic inches, or 10 lbs.
11·2 gals. = 1 cwt.
224 gals. = 1 ton.
1 cubic inch = 252·45 grs. or ·03617 lbs.
12 ,, inches = ·434 lbs.
1 ,, foot = 6·25 gals., or 1000 ozs., or 62·5 lbs.
1·8 ,, ,, = 1 cwt.
35·84 cubic feet = 1 ton.
1 cylindrical inch = ·02842 lbs.
12 ,, inches = ·341 lbs.
1 ,, foot = 5 gals., or 49·1 lbs.
2·282 ,, feet = 1 cwt.
45·64 ,, ,, = 1 ton.

Centre of pressure ⅔ depth from surface.

Water is at its maximum density at 39·2° Fahr. (40° C.), and expands 1-10th part of its bulk on freezing.

32° Fahr. . . . . Freezing point.
212° ,, ... Boiling ,,

1 cubic inch of mercury = 3425·25 grs.

Expansion of Liquids in Volume from 32° to 212° Fahr.

1000 parts of water	become	1046
,, oil	,,	1080
,, mercury	,,	1018
,, spirits of wine	,,	1110
,, air	,,	1373 to 1375

Luting for Experiments in Chemistry.

For temporarily securing the joints of chemical vessels, glass stoppers, &c., use equal parts by weight of linseed meal and whiting made into a stiff paste with water. The two substances should be well

ted in a mortar, and the water added till of the proper con-
y.

›s of vulcanized india-rubber tubing are very suitable for joining
ls of glass and earthenware tubes. The india-rubber is slipped
ıe ends, and secured with packthread.

ı rubber capsules for bottle necks, having a hole through them
insertion of glass tubes are handier, and more likely to be gas-
ıan the ordinary corks.

SPECIFIC HEAT OF SOLIDS AND LIQUIDS.

(Water as 1.)

acid	·6589	Lead	·0314
l (sp. gr. ·793)	·622	Lime, burned	·217
ıum	·2143	Lithium	·9408
›ny, cast	·05077	Magnesium	·2499
ꜫ	·0814	Manganese	·1217
ax	·45	Marble, white	.21585
e	·3952	Mercury	·03332
	·48	Nickel	·10863
;h	·03084	Oil, olive	·3096
	·09391	Oil, sweet	·31
common	·2	Oil of turpentine	·472
fire	·22	Palladium	·05928
ım	·05669	Phosphorus	·18949
white	·21485	Pine	·65
›al, animal, calcined	·26085	Platinum	·03243
›al, wood	·24111	Potassium	·1696
ʻhite, burned	·185	Selenium	·07616
	·2777	Silicon, crystalized	·1774
	·10696	Silicon, fused	·175
	·09215	Silver	·05701
nd	·14687	Sodium	·2934
	·5207	Spermaceti	·32
	·19768	Steel	·1175
	·03244	Sulphur	·20259
ite	·20187	Sulphuric acid	·333
	·504	Tellurium	·04737
	·05412	Thallium	·0336
ast	·12983	Tin	·05695
rought	·11379	Zinc	·09555

meaning implied in the term "specific heat," or more correctly,
ific capacity," is the quantity of heat required to raise the tem-
re of a substance 1° Fahr.—water being taken as the standard
parison.

example: the specific heat of mercury is ·03332, by which is to be
tood that thirty times as much heat is required to raise water
ʻen temperature as an equal weight of mercury. In other words,
antity of heat which would raise the temperature of any given
of mercury through 1° Fahr., would only raise the temperature
ce weight of water through ·03332°.

SUNDRY USEFUL INFORMATION RELATING TO GAS WORKS, GAS APPARATUS, GAS MANUFACTURE AND SUPPLY.

In chosing the site for a gas works, consideration should be had to its position, which should be at the lowest, or nearly the lowest part of the district, to obtain the advantage of the natural increase in the pressure of the gas in travelling to the higher levels.

It should, if possible, be alongside a railway, navigable river, or canal, for convenience in the delivery of coal and other materials, and the disposal of such of the residual products as are despatched to a distance.

The buildings and apparatus should not be squandered or sprawling over the site, occupying unnecessary space, but compact and harmonious, so that the different processes may be conveniently carried on, and economical in the working.

The buildings and plant should be so set out on the land as to admit of future extensions being made with ease and economy.

It is not necessary or desirable that the buildings of a gas works should be as strong as a castle; but it is a mistake to set up unstable and flimsy structures that entail an annual expenditure for repairs, enhancing the cost of working.

Excessive and unnecessary ornamentation is to be avoided in all work of this kind. All ornamentation, however, is not useless. Blank thick walls, for example, are not necessarily stronger than others well proportioned—thinner and lighter in parts, but strengthened by suitable projections, that add to the symmetry of a building, and break the dull uniformity.

The same remarks hold good as respects design in apparatus. Taste should not be neglected, and there is scope for the exercise of good taste in most departments of a gas works.

The design of a structure should be in keeping with the purpose for which the structure is intended.

Capital is best spent on substantial tanks and apparatus. Mere ornament should be a secondary consideration.

One of the evidences of good administrative skill in the conduct of a gas works, is the ensuring that extensions are carried out systematically and with foresight, and in a substantial manner. To postpone them to the very last extremity, or to erect makeshift buildings and apparatus, is to starve the concern, which is the worst policy possible for the undertaking and all connected therewith.

The average cost of gas works in provincial towns is about £1 per head of the population. In very large towns it will amount to more, and in very small towns it will scarcely reach that sum.

The average cost of gas works per million cubic feet of gas produced per annum is from £700 to £800; or at the rate of about 16s. per 1000 cubic feet.

The capital of a well-managed gas company does not usually amount to more than four times the annual gas rental. *Vice versâ*, the gas rental should be at least one-fourth of the capital. Reckoned on the *maximum* production of gas in 24 hours, the capital will amount to about 2s. 3d. per cubic foot.

The population per mile of main is usually about 2000 people. In densely populated towns it will rise to 3000; but in fashionable residential places, where the houses stand more apart, the population per mile of main will fall below 1000.

The usual consumption of gas per mile of main in large towns is from 2½ to 4 millions of cubic feet per annum; and in small towns from 2 to 3 millions.

The gas rental per mile of main usually ranges from £400 to £600 per annum.

The average consumption per head of the population in large towns is about 2000 cubic feet per annum; in small manufacturing towns about 1600 cubic feet, and in agricultural towns about 1000 to 1200 cubic feet per annum.

The usual annual increase in the consumption of gas is from 7 to 10 per cent. In rapidly growing districts it will range considerably higher.

TABLE

Showing the Time in which the Yearly Consumption of Gas will be Doubled, at different Annual Rates of Increase.

Rate per cent. of Increase per ann.	Time in which the Consumption will be Doubled.	Rate per cent. of Increase per ann.	Time in which the Consumption will be Doubled.	Rate per cent. of Increase per ann.	Time in which the Consumption will be Doubled.
2	35 years, 1 day.	5½	12 years, 345 days.	9	8 years, 16 days.
2½	28 years, 26 days.	6	11 years, 327 days.	9½	7 years, 233 days.
3	23 years, 164 days.	6½	11 years, 2 days.	10	7 years, 100 days.
3½	20 years, 54 days.	7	10 years, 89 days.	10½	6 years, 344 days.
4	17 years, 246 days.	7½	9 years, 218 days.	11	6 years, 234 days.
4½	15 years, 273 days.	8	9 years, 2 days.	11½	6 years, 184 days.
5	14 years, 75 days.	8½	8 years, 181 days.	12	6 years, 42 days.

TABLE

Showing the Approximate Sum (or the Equivalent of the Annuit paid for each £100 of Share Capital of Gas Companies on the p chase of the Gas Works by Municipal Corporations, Commission or Local Boards, in the several undermentioned Towns.

Name.	Year when Pur-chased.	Approximate Sum (or the Equivalent of the Annuities) paid for each £100 of Share Capital.	Remarks.
		£	
Aberdeen	1871	250	
Alloa	1877	232	
Arbroath	1871	175	
Ashton-in-Makerfield	1875	160	Non-statutory Company.
Atherton	1873	160	
Bangor	1878	250	
Belfast	1874	193	
Birkenhead	1858	220	
Birmingham	1875	196	
Birstal	1872	187	
Blackburn	1877	235	
Bolton	1872	204	
Bradford	1871	382	A sum of £162,856 had been pended out of profits in ext ing the works. Capitalizing sum, the amount paid per is only £96.
Briton Ferry	1873	210	
Broughty Ferry	1870	150	Non-statutory Company.
Burnley	1854	300	
Burslem	1877	222	
Bury (Lancashire)	1859	250	
Chorley	1871	250	
Cleckheaton	1870	205	
Clitheroe	1878	210	
Colne	1877	237	Non-statutory Company.
Darlington	1854	216	
Dewsbury and Batley	1873	205	
Droitwich	1878	149	Non-statutory Company.
Dukinfield	1877	250	
Dumbarton	1873	225	
Dumfries	1878	151	
Dundee	1868	160	
East Retford	1878	200	
Evesham	1878	129	
Forfar	1871	187	
Glasgow	1869	209	
Halifax	1856	250	
Hereford	1872	361	A sum of £24,000 had been pended out of profits in ext ing the works. Capitalizing sum, the amount paid per is £172.

Name.	Year when Purchased.	Approximate Sum (or the Equivalent of the Annuities) paid for each £100 of Share Capital.	Remarks.
		£	
ood	1867	208	
ey	1872	208	
astle	1876	117	Non-statutory Company. A sum of £8,000 had been expended out of profits on extending the works, which sum was capitalized.
ersfield	1872	204	
on	1878	177	Non-statutory Company.
ness	1875	158	
rnock	1872	150	
tilloch	1878	200	A sum of £1,800 had been expended out of profits on extending the works. Capitalizing this sum, the amount paid per £100 is £169.
	1870	140	
ter	1878	217	
	1874	200	
ndno	1876	175	
on	1877	200	
esfield	1861	250	
ield	1878	250	
ort	1876	118	
	1874	125	
n	1866	150	
ury	1878	130	Site belonged to Corporation, and works and plant taken at a valuation.
stle-under-Lyme	1881	250	
	1878	190	Non-statutory Company.
gham	1874	162	
n	1858	250	
Darwen	1873	188	
am and Hapton	1876	200	
y	1845	160	
h	1877	191	
	1871	156	
ale	1844	167	
ham	1870	205	
Walden	1878	111	Non-statutory Company.
lens	1876	272	
y Bridge	1861	159	
d	1878	262	
on-Trent	1878	250	
rd-upon-Avon	1879	188	
-in-Ashfield	1878	261	
ley	1865	167	
ton	1874	212	
gton	1877	240	
	1874	208	The Company were allowed to capitalize £12,500. Adding this to the share capital, the sum paid per £100 is £174.

AVERAGE COMPOSITION OF LONDON GAS BY VOLUME.

(*Dr. Letheby*, 1866.)

	Common Gas.	Cannel Gas.
Hydrogen	46·0	27·7
Light carburetted hydrogen	39·5	50·0
Olefiant gas	3·8	13·0
Carbonic oxide	7·5	6·8
Carbonic acid	0·7	0·1
Aqueous vapour	2·0	2·0
Nitrogen	0·5	0·4
	100·0	100·0

Relative Value of Different Illuminating Agents in Regard to their Illuminating Properties. (*Dr. Letheby*, 1866.)

Name.	Rate of Consumption per Hour.	Illum. Power. (Sperm, 120 grs.)	Quantity = 14 Candles.
Cannel Gas	4 feet	18·67	8 feet.
Coal Gas	5 „	14·00	5 „
Benzole	301 grs.	4·91	857 grs.
Paraffin Oil	265 „	7·11	522 „
Sperm Oil	686 „	10·00	960 „
Colza Oil	648 „	9·01	1008 „
Paraffin Candles	122 „	1·46	1171 „
Sperm „	132 „	1·35	1440 „
Wax „	168 „	1·43	1652 „
Stearic „	140 „	1·13	1732 „
Composite „	144 „	1·08	1858 „
Tallow „	145 „	0·83	2542 „

TABLE

Comparing Gas with the other Ordinary Light-giving Materials. (*Dr. Letheby.*)

5 cubic feet of common gas (at 4s. per 1000 cubic feet) give a light equal to—

2·5 Argand lamps, burning the best sperm oil at the rate of 133 grains per hour (price of sperm, 8s. per gallon); or,

23 mould tallow candles of six to the pound, each burning at the rate of 145 grains per hour (price 6d. per lb.); or,

18 common oil lamps, burning the best sperm oil at the rate of 133 grains per hour (price of sperm, 8s. per gallon); or,

13 sperm candles, six to the pound, each burning at the rate of 133 grains per hour (price 2s. per lb.); or,

15 composition candles, six to the pound, each burning at the rate of *136 grains per* hour (price 2s. per lb.); or,

16·25 **wax candles**, six to the pound, (2s. per lb.).

Estimating the cost of the gas and other light-giving materials at the price affixed, we have the next

TABLE

Showing the Relative Cost of the Various Illuminating Agents.

Gas	equal to	1
Sperm Oil burnt in Argands	,,	8
Mould tallow candles, six to the pound	,,	12
Sperm oil burnt in an open lamp	,,	17
Sperm candles, six to the pound	,,	24
Composition candles, six to the pound	,,	29
Wax candles, six to the pound	,,	30

In other words, 1s. worth of gas will go as far in the production of light as 8s. worth of sperm oil burnt in an Argand lamp, or 12s. worth of ordinary mould candles, or 17s. worth of sperm oil burnt in an open lamp, or 24s. worth of sperm candles, or 29s. worth of composition candles, or 30s. worth of wax candles.

TABLE.

*Showing the Relative Proportions which the Ordinary Light-giving **Materials** bear to* 1000 *Cubic Feet of* 13-*Candle Gas, as estimated by **Mr.** Lewis Thompson.*

1000 cub.ft. of common gas were found equal to the light of	$44\frac{4}{7}$ lbs. of sperm candles.
,, ,, ,,	$48\frac{6}{7}$ lbs. of carefully snuffed wax candles.
,, ,, ,,	$52\frac{9}{10}$ lbs. of best mould candles.
,, ,, ,,	$54\frac{3}{7}$ lbs. of best dip candles.
,, ,, ,,	$6\frac{1}{2}$ gallons of purified colza oil, Specific gravity, ·915
,, ,, ,,	$5\frac{9}{10}$ gallons of sperm oil. Specific gravity, ·888.

The comparative values of the different light-giving materials may be readily estimated from the foregoing tabular statement of relative proportions. Thus, for instance, if the cost of gas be 4s. 6d. per 1000 cubic feet, the cost of wax candles that yield an equal quantity of light, at 2s. 4d. per lb., would be £5 14s.

RELATIVE VALUES OF ILLUMINATING AGENTS,

In respect of their Heating and Vitiating Effects on the Atmosphere, when burning so as to Give the Light of 12 *Standard Sperm Candles.* (*Dr. Letheby.*)

	Pounds of Water Heated 1° Fahr.	Oxygen Consumed (Cubic Feet).	Carbonic Acid Produced (Cubic Feet).	Air Vitiated (Cubic Feet).
Cannel gas	1950	3·30	2·01	50·2
Common gas	2786	5·45	3·21	80·2
Sperm oil	2335	4·75	3·33	83·3
Benzole	2326	4·46	3·54	88·5
Paraffin	3619	6·81	4·50	112·5
Camphine	3251	6·65	4·77	119·2
Sperm candles	3517	7·57	5·27	131·7
Wax candles	3831	8·41	5·90	149·5
Stearic candles	3747	8·82	6·25	156·2
Tallow candles	5054	12·06	8·73	218·8 x

TABLE

Indicating the Comparative Salubrity of the Several Illuminating Materials.

The flame of coal gas; and the flames of several combustible bodies that gave an amount of light equal to it, were burned separately in given quantities of atmospheric air, and the times were noted at which the flames were extinguished by the contamination of the air. The following were the results:—

Colza oil	was extinguished	in	71	minutes
Olive oil	,,	,,	72	,,
Russian tallow	,,	,,	75	,,
Sperm oil	,,	,,	76	,,
Stearic acid	,,	,,	77	,,
Wax candles	,,	,,	79	,,
Spermaceti candles . .	,,	,,	83	,,
Coal Gas (13 candles). .	,,	,,	98	,,
Cannel Gas (28 candles).	,,	,,	152	,,

From which it appears that the atmosphere of a confined room lighted by cannel gas will support life twice as long as the atmosphere of the same room lighted equally by tallow candles.

Relative Cost of the Magnesium Light, Stearin Candles, and Common Coal Gas. (*Dr. Frankland*, 1865)

2½	oz. of magnesium wire, at 21s. per oz.	£2	12	6
20	lbs. of stearin candles, at 1s.	1	0	0
404	cubic feet of 12-candle gas, at 4s. 6d. per 1000	0	1	9⅘

TABLE.

Calorific Power of Various Photogenic Compounds (*F. J. Evans.*)

Name of Gas, &c.	Cubic Feet to One Pound.	Pounds of Water raised 1° by the Consumption of 1 Foot of Gas.	Pounds of Water raised 1° by the Consumption of 1 lb of Gas.
Hydrogen	180·0 . . .	300	54,000
Newcastle gas, sp. gr. ·410	32·4 . . .	650	21,060
Cannel gas, sp. gr. ·500 .	26·5 . . .	760	20,140
Oil gas, sp. gr. ·825 . . .	16·69 . . .	1200	19,300
			1 lb. of candles.
Sperm candles, 6 to the lb.			17,567
			1 lb. of oil.
Sperm oil, burnt in a lamp			16,480

TABLE

Showing the Cost of Gas per Hour in Fractions of a Penny, when Burnt at the following Rates per 1000 Cubic Feet :—

Consumption per Hour in Cubic Feet.	2s. 6d	2s. 7d.	2s. 8d.	2s. 9d.	2s.10d	2s.11d	3s. 0d.	3s. 1d.	3s. 2d.	3s. 3d.	3s. 4d.	3s. 5d.
2	·060	·062	·064	·066	·068	·070	·072	·074	·076	·078	·080	·082
2½	·075	·0775	·080	·0825	·085	·0875	·090	·0952	·095	·0975	·100	·1025
3	·090	093	·096	·099	·102	·105	·108	·111	·114	·117	·120	·123
3½	·105	·1085	·112	·1155	·119	·1225	·126	·1295	·133	·1365	·140	·1435
4	·120	·124	·128	·132	·136	·140	·144	·148	152	·156	·160	·164
4½	·135	·1395	·144	·1485	·153	·1575	·162	·1665	·171	·1755	·180	·1845
5	·150	·155	·160	·165	·170	·175	·180	·185	·190	·195	·200	·205
5½	·165	·1705	·176	·1815	·187	·1925	·198	·2035	·209	·2145	·220	·2255
6	·180	·186	·192	·198	·204	·210	216	·222	·228	·234	·240	·246
6½	·195	·2015	·208	·2145	·221	·2275	·234	·2405	·247	·2535	·260	·2665
7	·210	·217	·224	·231	·238	·245	·252	·259	·266	·273	·280	·287

Consumption per Hour in Cubic Feet.	3s. 6d.	3s. 7d.	3s. 8d.	3s. 9d.	3s.10d	3s.11d	4s. 0d.	4s. 1d.	4s 2d.	4s. 3d	4s. 4d.	4s. 5d.
2	·084	·086	·088	·090	·092	·094	·096	·098	·100	·102	·104	·106
2½	·105	·1075	·110	·1125	·115	·1175	·120	·1225	·125	·1275	·130	·1325
3	·126	·129	·132	·135	·138	141	·144	·147	·150	·153	156	·159
3½	·147	1505	·154	·1575	·161	·1645	·168	·1715	·175	·1785	·182	·1855
4	·168	·172	·176	·180	·184	·188	·192	·196	·200	·204	·208	·212
4½	·189	·1935	·198	·2025	·207	·2115	·216	·2205	·225	·2295	·234	·2385
5	·210	·215	·220	·225	·230	·235	·240	·245	·250	·255	·260	·265
5½	·231	·2365	·242	·2475	·253	·2585	·264	·2695	·275	·2805	·286	·2915
6	·252	·258	·264	·270	·276	·282	288	·294	300	·306	·312	·318
6½	·273	·2795	·286	·2925	·299	·3055	·312	·3185	·325	·3315	·338	·3445
7	·294	·301	·308	·315	·322	·329	·336	·343	·350	·357	·364	·371

Consumption per Hour in Cubic Feet.	4s. 6d.	4s. 7d.	4s. 8d.	4s. 9d.	4s.10d	4s.11d	5s. 0d.	5s. 1d.	5s. 2d.	5s. 3d.	5s. 4d.	5s. 5d.
2	·108	·110	·112	·114	·116	·118	·120	·122	·124	·126	·128	·130
2½	·135	·1375	·140	·1425	·145	·1475	·150	·1525	·155	·1575	·160	·1625
3	·162	·165	168	·171	·174	·177	·180	·183	·186	·189	·192	·195
3½	·189	·1925	·196	·1995	203	·2065	·210	·2135	·217	·2205	224	·2275
4	·216	·220	·224	·228	·232	·236	·240	·244	·248	·252	·256	·260
4½	·243	·2475	·252	·2565	·261	·2655	·270	·2745	·279	·2835	·288	·2925
5	·270	·275	·280	·285	·290	·295	·300	·305	310	·315	·320	·325
5½	·297	·3025	·308	·3135	·319	·3245	·330	·3355	·341	·3465	·352	·3575
6	·324	·330	·336	·342	348	·354	·360	·366	·372	·378	·384	·390
6½	·351	·3575	·364	·3705	·377	·3835	·390	·3965	·403	·4095	·416	·4225
7	·378	·385	·392	·399	·406	·413	·420	·427	·434	441	·448	·455

Consmp. per Hour in Cb. Ft.	5s. 6d.	5s. 7d.	5s. 8d.	5s. 9d.	5s.10d	5s.11d	6s. 0d.	6s. 1d.	6s. 2d.	6s. 3d.	6s. 4d.	6s. 5d.	6s. 6d
2	·132	·134	136	·138	·140	·142	·144	·146	·148	·150	·152	·154	·156
2½	·165	·1675	·170	·1725	·175	·1775	·180	·1825	·185	·1875	·190	·1925	·195
3	·198	·201	204	·207	·210	·213	·216	·219	·222	·225	·228	·231	·234
3½	·231	·2345	·238	·2415	·245	·2485	·252	·2555	·259	2625	·266	·2695	·273
4	·264	·268	·272	·276	280	·284	·288	·292	296	·300	·304	·308	·312
4½	·297	·3015	·306	·3105	·315	·3195	·324	·3285	·333	3375	·342	·3465	·351
5	·330	335	·340	·345	350	355	·360	·365	·370	·375	·380	·385	·390
5½	·363	·3685	·374	·3795	·385	·3905	·396	·4015	·407	·4125	·418	·4235	·429
6	·396	·402	·408	·414	420	·426	·432	·438	·444	·450	·456	·462	·468
6½	·429	·4355	·442	·4485	·455	·4615	·468	·4745	·481	·4875	·494	·5005	·507
7	·462	·469	·476	·483	·490	·497	·504	·511	518	·525	·532	·539	·546

x 2

GOLDEN RULES FOR GAS MANAGERS.*

Keep up the heats of the retorts.
Keep up the efficiency of the meters.
Keep down the pressure in the mains.
Keep down the arrears in the gas ledger.

MISCELLANEOUS.

BRICKS AND BRICKWORK.

Usual Dimensions of Bricks.

9 inches long; 4½ inches broad; 2¾ inches thick.

Weight of 1000 common clay bricks, about 3¼ tons.
Weight of 1000 fire-clay bricks, about 3⅓ tons.
305 common clay bricks weigh about 1 ton.
300 fire-clay bricks weigh about 1 ton.
32 bricks laid flat will pave one square yard.
52 bricks laid on edge will pave one square yard.
Number of bricks in a cubic yard, without mortar, 416.
Number of bricks in a cubic yard, with mortar, 384.
In England, brickwork is generally calculated by the square rod.

A rod of brickwork measures 16½ feet × 16½ feet × 1⅛ foot = 306 cubic feet, or 11⅓ cubic yards.

A rod of brickwork = 272 superficial feet, 1½ brick, or 13½ inches thick, which is called the *standard* thickness.

Number of bricks in a rod of brickwork, allowing for waste, 4,500.

To reduce brickwork from superficial feet of 9 inches thick to the standard thickness of 13½ inches, deduct one-third.

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* These rules are as applicable to-day as they were on the first day they were penned, as they embody all the philosophy of gas management. A strict adherence to the advice which they give will ensure the success of any gas undertaking, just as a disregard of them will result in loss and disaster.

It has been attempted (with little success, and less reason) to impugn the utility of the 3rd rule. To keep down the pressure in the day time, say certain writers and speakers, is to discourage the use of gas for cooking and heating. But, surely, to make such a remark is to betray an amount of dulness not easy to understand. It should be obvious to the meanest comprehension that it is not advised that the pressure should be kept down to an abnormal rate. Whatever pressure is required either by day or night must of course be maintained; *the rule indeed* implies as much, but it implies something more—its object is to *discountenance* the maintenance of a *wasteful* pressure, and all pressure in *excess of actual* requirements is wasteful. *Verbum sat sapienti.*

To reduce brickwork from cubic feet to superficial feet of the standard thickness of 13½ inches, deduct one ninth.

To reduce brickwork from cubic feet to rods, divide by 306.

To reduce brickwork of more than 1½ bricks thick to superficial feet of the standard thickness of 13½ inches, multiply the area in feet by the number of half bricks in thickness, and divide the product by 3.

To reduce brickwork footings to superficial feet of the standard thickness of 13½ inches, multiply the length by the height of the courses, in feet, and the product by the number of half bricks in the *mean* breadth, and divide by 3. When the number of courses is odd, the number of half bricks in the middle course is the mean. When the number of courses is even, the mean breadth is found by taking half the sum of half bricks in the upper and lower courses.

Bond in Brickwork.

English bond is the strongest, and is a course of stretchers and a course of headers alternately, or one course of headers and one course of stretchers.

Flemish bond is a header and stretcher laid alternately in the same course.

Hoop-iron, when used as bond, should be well tarred and sanded, and bedded in Portland cement.

A rod of brickwork in ordinary buildings requires about—

1 cubic yard of lime.
2¾ cubic yards of sand.

A rod of brickwork in a gasholder tank requires about—

1⅖ cubic yards of blue lias lime.
2⅘ cubic yards of sharp river sand.

A rod of brickwork requires about—

1¾ cubic yards of Roman or Portland cement.
1¾ cubic yards of sharp river sand.

A cubic yard of	quicklime . . .	weighs	about	1460	lbs.
„ „	blue lias quicklime	„	„	1470	„
„ „	Portland cement	„	„	2416	„
„ „	Roman cement	„	„	1700	„
„ „	dry sand weighs	„	„	2430	„

The above materials, when made into mortar, lose about one-third of their bulk.

TABLES

Showing the Number of Bricks in Walls of different Areas, from ½ a Brick up to 4 Bricks thick. Reckoned at 4,500 Bricks to the Rod (272 feet super.), allowing for Waste.

TABLE I.—*From 1 to 50 Superficial Feet.*

Area of Wall. Sup. Feet.	½ Brick on Bed.	1 Brick thick.	1½ Bricks thick.	2 Bricks thick.	2½ Bricks thick.	3 Bricks thick.	3½ Bricks thick.	4 Bricks thick.
1	6	11	17	22	28	33	39	44
2	11	22	33	44	55	66	77	88
3	17	33	50	66	83	99	116	132
4	22	44	66	88	110	132	154	176
5	28	55	83	110	138	165	193	221
6	33	66	99	132	165	199	232	265
7	39	77	116	154	193	232	270	309
8	44	88	132	176	221	265	309	353
9	50	99	149	199	248	298	347	397
10	55	110	165	221	276	331	386	441
11	61	121	182	243	303	364	425	485
12	66	132	199	265	331	397	463	529
13	72	143	215	287	358	430	502	574
14	77	154	232	309	386	463	540	618
15	83	165	248	331	414	496	579	662
16	88	176	265	353	441	529	618	706
17	94	187	281	375	469	563	656	750
18	99	199	298	397	496	596	695	794
19	105	210	314	419	524	629	733	838
20	110	221	331	441	551	662	772	882
21	116	232	347	463	579	695	811	926
22	121	243	364	485	607	728	849	971
23	127	254	381	507	634	761	888	1015
24	132	265	397	529	662	794	926	1059
25	138	276	414	551	689	827	965	1103
26	143	287	430	574	717	860	1004	1147
27	149	298	447	596	744	893	1042	1191
28	154	309	463	618	772	926	1081	1235
29	160	320	480	640	800	960	1119	1279
30	165	331	496	662	827	993	1158	1324
31	171	342	513	684	855	1026	1197	1368
32	176	353	529	706	882	1059	1235	1412
33	182	364	546	728	910	1092	1274	1456
34	188	375	563	750	938	1125	1313	1500
35	193	386	579	772	965	1158	1351	1544
36	199	397	596	794	993	1191	1390	1588
37	204	408	612	816	1020	1224	1428	1632
38	210	419	629	838	1048	1257	1467	1676
39	215	430	645	860	1075	1290	1506	1721
40	221	441	662	882	1103	1324	1544	1765
41	226	452	678	904	1131	1357	1583	1809
42	232	463	695	926	1158	1390	1621	1853
43	237	474	711	949	1186	1423	1660	1897
44	243	485	728	971	1213	1456	1699	1941
45	248	496	744	993	1241	1489	1737	1985
46	254	507	761	1015	1268	1522	1776	2029
47	259	518	778	1037	1296	1555	1814	2074
48	265	529	794	1059	1324	1588	1853	2118
49	*270*	540	811	1081	1351	1621	1892	2162
50	*276*	551	827	1103	1379	1654	1930	2206

TABLES

Showing the Number of Bricks in Walls of different Areas, from ½ a Brick up to 4 Bricks thick. Reckoned at 4,500 Bricks to the Rod (272 feet super.), allowing for Waste.

TABLE II.—*From 51 to 100 Superficial Feet.*

Area of Wall. Sup. Feet.	½ Brick on Bed.	1 Brick thick.	1½ Bricks thick.	2 Bricks thick.	2½ Bricks thick.	3 Bricks thick.	3½ Bricks thick.	4 Bricks thick.
51	281	563	844	1125	1406	1688	1969	2250
52	287	574	860	1147	1434	1721	2007	2294
53	292	584	877	1169	1461	1754	2046	2338
54	298	596	893	1191	1489	1787	2085	2382
55	303	607	910	1213	1517	1820	2123	2426
56	309	618	926	1235	1544	1853	2162	2471
57	314	629	943	1257	1572	1886	2200	2515
58	320	640	960	1279	1599	1919	2239	2559
59	325	651	976	1301	1627	1952	2278	2603
60	331	662	993	1323	1654	1985	2316	2647
61	336	673	1009	1346	1682	2018	2355	2691
62	342	684	1026	1368	1710	2051	2393	2735
63	347	695	1042	1390	1737	2085	2432	2779
64	353	706	1059	1412	1765	2118	2471	2824
65	358	717	1075	1434	1792	2151	2509	2868
66	364	728	1092	1456	1820	2184	2548	2912
67	369	739	1108	1478	1847	2217	2586	2956
68	375	750	1125	1500	1875	2250	2625	3000
69	381	761	1142	1522	1903	2283	2664	3044
70	386	772	1158	1544	1939	2316	2702	3088
71	392	783	1175	1566	1958	2349	2741	3132
72	397	794	1191	1588	1985	2382	2779	3177
73	403	805	1208	1610	2013	2415	2818	3221
74	408	816	1224	1632	2040	2449	2857	3265
75	414	827	1241	1654	2068	2482	2895	3309
76	419	838	1257	1676	2096	2515	2934	3353
77	425	849	1274	1699	2123	2548	2972	3397
78	430	860	1290	1721	2151	2581	3011	3441
79	436	871	1307	1743	2178	2614	3050	3485
80	441	882	1324	1765	2206	2647	3088	3529
81	447	893	1340	1787	2233	2680	3127	3574
82	452	904	1357	1809	2261	2713	3165	3618
83	458	915	1373	1831	2289	2746	3204	3662
84	463	926	1390	1853	2316	2779	3243	3706
85	469	938	1406	1875	2344	2813	3281	3750
86	474	949	1423	1897	2371	2846	3320	3794
87	480	960	1439	1919	2399	2879	3358	3838
88	485	970	1456	1941	2426	2912	3397	3882
89	491	982	1472	1963	2454	2945	3436	3926
90	496	993	1489	1985	2482	2978	3474	3971
91	502	1004	1506	2007	2509	3011	3513	4015
92	507	1015	1522	2029	2537	3044	3551	4059
93	513	1026	1539	2051	2564	3077	3590	4103
94	518	1037	1555	2074	2592	3110	3629	4147
95	524	1048	1572	2096	2619	3143	3667	4191
96	529	1059	1588	2118	2647	3176	3706	4235
97	535	1070	1605	2140	2675	3210	3744	4279
98	540	1081	1621	2162	2702	3243	3783	4324
99	546	1092	1638	2184	2730	3276	3822	4368
100	551	1103	1654	2206	2757	3309	3860	4412

TABLES

Showing the Number of Bricks in Walls of different Areas, from ½ a Brick up to 4 Bricks thick. Reckoned at 4,500 Bricks to the Rod (272 feet super.), allowing for Waste.

TABLE III.—*From* 110 *to* 600 *Superficial Feet.*

Area of Wall. Sup. Feet.	½ Brick on Bed.	1 Brick thick.	1½ Bricks thick.	2 Bricks thick.	2½ Bricks thick.	3 Bricks thick.	3½ Bricks thick.	4 Bricks thick.
110	607	1213	1820	2426	3033	3640	4246	4853
120	662	1324	1985	2647	3309	3971	4632	5294
130	717	1434	2151	2868	3585	4301	5018	5735
140	772	1544	2316	3088	3860	4632	5404	6176
150	827	1654	2482	3309	4136	4963	5790	6618
160	882	1765	2647	3529	4412	5294	6176	7059
170	938	1875	2813	3750	4688	5625	6563	7500
180	993	1985	2978	3971	4963	5956	6949	7941
190	1048	2096	3143	4191	5239	6287	7335	8382
200	1103	2206	3309	4412	5515	6618	7721	8824
210	1158	2316	3474	4632	5790	6949	8107	9265
220	1213	2426	3640	4853	6066	7279	8493	9706
230	1268	2537	3805	5074	6342	7610	8879	10,147
240	1324	2647	3971	5294	6618	7941	9265	10,588
250	1379	2757	4136	5515	6893	8272	9651	11,029
260	1434	2868	4301	5735	7169	8603	10,037	11,471
270	1489	2978	4467	5956	7445	8934	10,423	11,912
280	1544	3088	4632	6176	7721	9265	10,809	12,353
290	1599	3199	4798	6397	7996	9596	11,195	12,794
300	1654	3309	4963	6618	8272	9926	11,581	13,235
310	1710	3419	5129	6838	8548	10,257	11,967	13,676
320	1765	3529	5294	7059	8824	10,588	12,353	14,118
330	1820	3640	5460	7279	9099	10,919	12,739	14,559
340	1875	3750	5625	7500	9375	11,250	13,125	15,000
350	1930	3860	5790	7721	9651	11,581	13,511	15,441
360	1985	3971	5956	7941	9926	11,912	13,897	15,882
370	2040	4081	6121	8162	10,202	12,243	14,283	16,324
380	2096	4191	6287	8382	10,478	12,574	14,669	16,765
390	2151	4301	6452	8603	10,754	12,904	15,055	17,206
400	2206	4412	6618	8824	11,029	13,235	15,441	17,647
410	2261	4522	6783	9044	11,305	13,566	15,827	18,088
420	2316	4632	6949	9265	11,581	13,897	16,213	18,529
430	2371	4743	7114	9485	11,857	14,228	16,599	18,971
440	2426	4853	7279	9706	12,132	14,559	16,985	19,412
450	2482	4963	7445	9926	12,408	14,890	17,371	19,853
460	2537	5074	7610	10,147	12,684	15,221	17,757	20,294
470	2592	5184	7776	10,368	12,960	15,551	18,143	20,735
480	2647	5294	7941	10,588	13,235	15,882	18,529	21,176
490	2702	5404	8107	10,809	13,511	16,213	18,915	21,618
500	2757	5515	8272	11,029	13,787	16,544	19,301	22,059
510	2813	5625	8438	11,250	14,063	16,875	19,688	22,500
520	2868	5735	8603	11,471	14,338	17,206	20,074	22,941
530	2923	5846	8768	11,691	14,604	17,537	20,460	23,382
540	2978	5956	8934	11,912	14,890	17,868	20,846	23,824
550	3033	6066	9099	12,132	15,165	18,199	21,232	24,265
560	3088	6176	9265	12,353	15,441	18,529	21,618	24,706
570	3143	6287	9430	12,574	15,717	18,860	22,004	25,147
580	3199	6397	9596	12,794	15,993	19,191	22,390	25,588
590	3254	6507	9761	13,015	16,268	19,522	22,776	26,029
600	3309	6618	9926	13,235	16,544	19,853	23,162	26,471

TABLES

Showing the Number of Bricks in Walls of different Areas, from ½ a Brick up to 4 Bricks thick. Reckoned at 4,500 Bricks to the Rod (272 feet super.), allowing for Waste.

TABLE IV.—*From* 610 *to* 2000 *Superficial Feet.*

Area of Wall. Sup. Feet.	½ Brick on Bed.	1 Brick thick.	1½ Bricks thick.	2 Bricks thick.	2½ Bricks thick.	3 Bricks thick.	3½ Bricks thick.	4 Bricks thick.
610	3364	6728	10,092	13,456	16,820	20,184	23,548	26,912
620	3419	6838	10,257	13,676	17,096	20,515	23,934	27,353
630	3474	6949	10,423	13,897	17,371	20,846	24,320	27,794
640	3529	7059	10,588	14,118	17,647	21,176	24,706	28,235
650	3585	7169	10,754	14,338	17,923	21,507	25,092	28,676
660	3640	7279	10,919	14,559	18,199	21,838	25,478	29,118
670	3695	7390	11,085	14,779	18,474	22,169	25,864	29,559
680	3750	7500	11,250	15,000	18,750	22,500	26,250	30,000
690	3805	7610	11,415	15,221	19,026	22,831	26,636	30,441
700	3860	7721	11,581	15,441	19,301	23,162	27,022	30,882
710	3915	7831	11,746	15,662	19,577	23,493	27,408	31,324
720	3971	7941	11,912	15,882	19,853	23,824	27,794	31,765
730	4026	8051	12,077	16,103	20,129	24,154	28,180	32,206
740	4081	8162	12,243	16,324	20,404	24,485	28,566	32,647
750	4136	8272	12,408	16,544	20,680	24,816	28,952	33,088
760	4191	8382	12,574	16,765	20,956	25,147	29,338	33,529
770	4246	8493	12,739	16,985	21,232	25,478	29,724	33,971
780	4301	8603	12,904	17,206	21,507	25,809	30,110	34,412
790	4357	8713	13,070	17,426	21,783	26,140	30,496	34,853
800	4412	8824	13,235	17,647	22,059	26,471	30,882	35,294
810	4467	8934	13,401	17,868	22,335	26,801	31,268	35,735
820	4522	9044	13,566	18,088	22,610	27,132	31,654	36,176
830	4577	9154	13,732	18,309	22,886	27,463	32,040	36,618
840	4632	9265	13,897	18,529	23,162	27,794	32,426	37,059
850	4688	9375	14,063	18,750	23,438	28,125	32,813	37,500
860	4743	9485	14,228	18,971	23,713	28,456	33,199	37,941
870	4798	9596	14,393	19,191	23,989	28,787	33,585	38,382
880	4853	9706	14,559	19,412	24,265	29,118	33,971	38,824
890	4908	9816	14,724	19,632	24,540	29,449	34,357	39,265
900	4963	9926	14,890	19,853	24,816	29,779	34,743	39,706
910	5018	10,037	15,055	20,074	25,092	30,110	35,129	40,147
920	5074	10,147	15,221	20,294	25,368	30,441	35,515	40,588
930	5129	10,257	15,386	20,515	25,643	30,772	35,901	41,029
940	5184	10,368	15,551	20,735	25,919	31,103	36,287	41,471
950	5239	10,478	15,717	20,956	26,195	31,434	36,673	41,912
960	5294	10,588	15,882	21,176	26,471	31,765	37,059	42,353
970	5349	10,699	16,048	21,397	26,746	32,096	37,445	42,794
980	5404	10,809	16,213	21,618	27,022	32,426	37,831	43,235
990	5460	10,919	16,379	21,838	27,298	32,757	38,217	43,676
1000	5515	11,029	16,544	22,059	27,574	33,088	38,603	44,118
1100	6066	12,132	18,199	24,265	30,331	36,397	42,463	48,529
1200	6618	13,235	19,853	26,471	33,088	39,706	46,324	52,941
1300	7169	14,338	21,507	28,676	35,846	43,015	50,184	57,353
1400	7721	15,441	23,162	30,882	38,603	46,324	54,044	61,765
1500	8272	16,544	24,816	33,088	41,360	49,632	57,904	66,176
1600	8824	17,647	26,471	35,294	44,118	52,941	61,765	70,588
1700	9375	18,750	28,125	37,500	46,825	56,250	65,625	75,000
1800	9926	19,853	29,779	39,706	49,632	59,559	69,485	79,412
1900	10,478	20,956	31,434	41,912	52,390	62,868	73,346	83,824
2000	11,029	22,059	33,088	44,118	55,147	66,176	77,206	88,[illegible]

TABLES

Showing the Number of Bricks in Walls of different Areas, from ½ a Brick up to 4 Bricks thick. Reckoned at 4,500 Bricks to the Rod (272 feet super.), allowing for Waste.

TABLE V.—*From 2100 to 250,000 Superficial Feet.*

Area of Wall. Sup. Feet.	½ Brick on Bed.	1 Brick thick.	1½ Bricks thick.	2 Bricks thick.	2½ Bricks thick.	3 Bricks thick.	3½ Bricks thick.	4 Bricks thick.
2100	11,581	23,162	34,743	46,324	57,904	69,485	81,066	92,647
2200	12,132	24,265	36,397	48,529	60,662	72,794	84,926	97,059
2300	12,684	25,368	38,051	50,735	63,419	76,103	88,787	101,471
2400	13,235	26,471	39,706	52,941	66,176	79,412	92,647	105,882
2500	13,787	27,574	41,360	55,147	68,934	82,721	96,507	110,294
2600	14,338	28,676	43,015	57,353	71,691	86,029	100,368	114,706
2700	14,890	29,779	44,669	59,559	74,449	89,338	104,228	119,118
2800	15,441	30,882	46,324	61,765	77,206	92,647	108,088	123,529
2900	15,993	31,985	47,978	63,971	79,963	95,956	111,949	127,941
3000	16,544	33,088	49,632	66,176	82,721	99,265	115,809	132,353
3100	17,096	34,191	51,287	68,382	85,478	102,574	119,669	136,765
3200	17,647	35,294	52,941	70,588	88,235	105,882	123,529	141,176
3300	18,199	36,397	54,596	72,794	90,993	109,191	127,390	145,588
3400	18,750	37,500	56,250	75,000	93,750	112,500	131,250	150,000
3500	19,301	38,603	57,904	77,206	96,507	115,809	135,110	154,412
3600	19,853	39,706	59,559	79,412	99,265	119,118	138,971	158,824
3700	20,404	40,809	61,213	81,618	102,022	122,426	142,831	163,235
3800	20,956	41,912	62,868	83,824	104,779	125,735	146,691	167,647
3900	21,507	43,015	64,522	86,029	107,537	129,044	150,551	172,059
4000	22,059	44,118	66,176	88,235	110,294	132,353	154,412	176,471
4100	22,610	45,221	67,831	90,441	113,051	135,662	158,272	180,882
4200	23,162	46,324	69,485	92,647	115,809	138,971	162,132	185,294
4300	23,713	47,426	71,140	94,853	118,566	142,279	165.993	189,706
4400	24,265	48,529	72,794	97,059	121,324	145,588	169,853	194,118
4500	24,816	49,632	74,449	99,265	124,081	148,897	173,713	198,529
4600	25,368	50,735	76,103	101.471	126,838	152,206	177,574	202,941
4700	25,919	51,838	77,757	103,676	129,596	155,515	181,434	207,353
4800	26,471	52,941	79,412	105,882	132,353	158,824	185,294	211,765
4900	27,022	54,044	81,066	108,088	135,110	162,132	189,154	216,176
5000	27,574	55,147	82,721	110,294	137,868	165,441	193,015	220,588
10,000	55,147	110,294	165,441	220,588	275,735	330,882	386,029	441,176
15,000	82,721	165,441	248,162	330,882	413,603	496,324	579,044	661,765
20,000	110,294	220,588	330,882	441,176	551,471	661,765	772,059	882,353
25,000	137,868	275,735	413,603	551,471	689,338	827,206	965,074	1,102,941
30,000	165,441	330,882	496,324	661,765	827,206	992,647	1,158,088	1,323,529
35,000	193,015	386,029	579,044	772·059	965,074	1,158,088	1,351,103	1,544,118
40,000	220,588	441,176	661,765	882,353	1,102,941	1,323,529	1,544,118	1,764,706
45,000	248,162	496,324	744,485	992,647	1,240,809	1,488,971	1,737,132	1,985,294
50,000	275,735	551,471	827,206	1,102,941	1,378,676	1,654,412	1,930,147	2,205,882
55,000	303,309	606,618	909,926	1,213,235	1,516,544	1,819,753	2,123,162	2,426,471
60,000	330,882	661,765	992,647	1,323,529	1,654,412	1,985,294	2,316,176	2,647,059
65,000	358,456	716,912	1,075,368	1,433,824	1,792,279	2,150,735	2,509,191	2,867,647
70,000	386,029	772,059	1,158,088	1,544,118	1,930,147	2,316,176	2,702,206	3,088,235
75,000	413,603	827,206	1,240,809	1,654,412	2,068,015	2,481,618	2,895,221	3,308,824
80,000	441,176	882,353	1,323,529	1,764,706	2,205,882	2,647,059	3,088,235	3,529,412
85,000	468,750	937,500	1,406,250	1,875,000	2,343,750	2,812,500	3,281,250	3,750,000
90,000	496,324	992,647	1,488,971	1,985,294	2,481,618	2,977,941	3,474,265	3,970,588
95,000	523,897	1,047,794	1,571,791	2,095,588	2,619,485	3,143,382	3,667,279	4,191,176
100,000	551,471	1,102,941	1,654,412	2,205,882	2,757,353	3,308,824	3,860,294	4,411,765
150,000	827,206	1,654,412	2,481,618	3,308,824	4,136,029	4,963,235	5,790,441	6,617,647
200,000	*1,102,941*	2,205,882	3,308,824	4,411,765	5,514,706	6,617,647	7,720,588	8,823,529
250,000	*1,378,676*	2,757,353	4,136,029	5,514,706	6,893,382	8,272,059	9,650,735	11,029,412

MORTAR AND CONCRETE.

Mortar.

	By Measure.
Lime	1 part.
Sharp river sand	3 parts.
or,	
Lime	1 part.
Sand	2 parts.
Blacksmith's ashes or hard coke, ground	1 part.

Coarse Mortar.

Lime	1 part.
Coarse sand	4 parts.

Hydraulic Lime Mortar

Best blue lias lime	1 part.
Clean sharp river sand	2 parts.
or,	
Best blue lias lime	1 part.
Burnt clay	2½ parts.
or,	
Best blue lias lime	1 part.
Puzzolana	1 part.
Clean sharp sand	6 parts.

Cement Mortar.

Cement, Portland	1 part.
Clean sharp sand	3 parts.

The lime should be fresh burnt, and not more than sufficient of the mortar for a day's work prepared at once. The cement mortar should only be made as it is being used.

Concrete.

Blue lias lime concrete (for foundations)—	By Measure.
Gravel, shingle, broken stone, bricks, or old retorts, 1½ to 2 inches cube	6 parts.
Clean sharp sand	2 parts.
Blue lias or other hydraulic lime	1 part.
Portland cement concrete (for tank walls)—	
Gravel, shingle, broken stone, bricks, or old retorts, 1½ inches cube	7 parts.
Clean sharp sand	2 parts.
Portland cement	1 part.

Mastic Cement for Buildings.

1 part red lead.	1 part red lead.
5 parts ground lime.	5 parts whiting.
5 parts sharp sand.	10 parts sharp sand.
Mix with boiled linseed oil.	Mix with boiled linseed oil.

Clean sharp sand (not having its particles rounded by attrition) should always be used in the composition of mortar when it can be procured; but, otherwise, clean well-burnt ashes may be substituted.

In preparing ordinary mortar it is desirable to mix a small proportion of smithy ashes with the lime and sand. On this subject Mr. Graham Smith remarks ("Engineering Papers," p. 20) : "The importance of the admixture of ashes with mortar to be atmospherically dried will be shown by the following results : The bricklayers' mortar, with common bricks, after a lapse of 84 days, broke with 570 lbs.; when sand was substituted in place of ashes—that is, when the proportions were, 1 slaked lime, 2 sand, and no ashes—it only required 257 lbs. to tear asunder the bricks. These are the averages of three experiments. This is no doubt attributable to the ashes being porous; they thus allow greater facilities for the absorption of carbonic acid from the atmosphere."

The more sand that can be incorporated with the lime the better the mortar, provided the necessary degree of plasticity is preserved.

A load of mortar is equal to one cubic yard.

A hod of mortar measures 9 in. × 9 in. × 14 in.

Two hods of mortar are nearly equal to a bushel.

The mortar in a rod of brickwork (4500 bricks) is taken at 1½ cwt. of chalk lime and 2 loads of sand, or 1 cwt. of stone lime and 2½ loads of sand.

Fire-Clay.

The value of a fire-clay consists chiefly in the proportion of the alumina to the fusible matter (viz., oxide of iron, and the alkalies of magnesia, potassa and soda, &c.) and to the silica; these being the principal ingredients of which it is composed. The larger the proportion of alumina to the fusible matter, the more refractory the clay. Of two clays containing alumina and fusible matter in the same proportions, that which contains the least silica is the more refractory.

The celebrated clays of Stourbridge, Newcastle-on-Tyne, different parts of Scotland, and a few other places, are valuable in the manufacture of bricks, tiles, and retorts used in furnaces for the distillation of coal.

The table on next page will be found useful in this connection.

TABLE

Exhibiting the usual Constituents of the chief English and Foreign Fire-Clays.

Locality.	Silica.	Alumina.	Peroxide of Iron.	Peroxide of Manganese.	Phosphate of Iron.	Lime.	Magnesia	Potassa.	Soda.	Titanic Acid.	Water, Organic Matter, &c.	Total.
Stourbridge	65·37	26·48	5·68	..	..	·28	·33	1·26	·30	·30	..	100
Plympton, Devonshire . .	74·02	21·37	1·94	..	..	·40	·36	1·82	·09	..	..	100
Newcastle-on-Tyne . . .	64·63	29·78	3·23	..	..	·42	·41	1·09	·24	·20	..	100
Burton-on-Trent	58·08	36·09	3·06	..	..	·55	·14	·20	1·88	..	..	100
Wortley, near Leeds . . .	65·25	29·71	3·07	..	..	·40	·61	·43	·12	·41	..	100
Derbyshire	48·08	36·89	2·26	..	..	..	..	1·88	..	..	10·89	100
Hedgerley, Bucks* . . .	84·65	8·85	4·25	..	..	1·90	·35	..	..	..	..	100
Poole, Dorsetshire . . .	59·35	34·32	2·35	..	..	·43	·22	3·33	..	..	..	100
Monmouthshire	75·30	16·80	1·00	..	..	·90	..	..	..	..	6·00	100
Pembrokeshire . . .	88·43	6·90	1·50	..	..	3·17	..	..	..	..	..	100
Dinas, Glamorganshire . .	97·62	1·40	·49	..	..	·29	..	·10	·10	..	..	100
Kilmarnock, Scotland . .	58·92	35·65	2·49	..	..	·39	·35	1·14	1·06	..	..	100
Perceton, Scotland . . .	62·50	35·00	·90	·20	·50	·60	·30	..	..	..	..	100
Govan, Scotland	60·20	37·70	1·10	..	..	1·00	..	..	..	..	..	100
France	66·10	19·80	..	..	..	..	..	..	..	..	14·10	100
Hesse.	47·50	34·37	1·24	..	..	..	1·00	..	..	..	15·89	100
Bavaria	45·79	28·10	6·55	..	..	..	..	..	..	..	19·56	100

Authorities—Berthier, Cowper, Salvett, Muspratt, Richardson, Mr. Alfred Kitt, and Lieut. G. E. Grover.

* Windsor bricks.

Handy Multiplier for Wrought-Iron.

If the area in square inches of the cross section of any specimen of wrought-iron be multiplied by 3·34, the product will give the weight of a lineal foot of such specimen in lbs.

FLAT BAR IRON.

Weight of a Lineal Foot in lbs.

Breadth in Inches.	Thickness in Parts of an Inch								
	1-4th.	5-16ths.	3-8ths.	7-16ths.	1-half.	5-8ths.	3-4ths.	7-8ths.	1
1	·835	1·044	1·253	1·461	1·670	2·088	2·506	2·923	3·340
1⅛	·939	1·174	1·409	1·644	1·878	2·348	2·818	3·287	3·756
1¼	1·044	1·305	1·566	1·826	2·088	2·609	3·132	3·653	4·176
1⅜	1·148	1·435	1·722	2·009	2·296	2·870	3·444	4·018	4·592
1½	1·252	1·566	1·879	2·192	2·504	3·131	3·758	4·384	5·008
1⅝	1·358	1·696	2·035	2·374	2·716	3·392	4·070	4·749	5·432
1¾	1·462	1·827	2·192	2·557	2·924	3·653	4·384	5·114	5·848
1⅞	1·566	1·957	2·348	2·740	3·132	3·914	4·696	5·479	6·264
2	1·671	2·088	2·505	2·922	3·342	4·175	5·010	5·845	6·684
2⅛	1·775	2·218	2·662	3·105	3·550	4·485	5·324	6·210	7·100
2¼	1·880	2·348	2·818	3·288	3·760	4·696	5·636	6·575	7·520
2⅜	1·984	2·479	2·975	3·470	3·968	4·957	5·950	6·941	7·936
2½	2·088	2·609	3·131	3·653	4·176	5·218	6·262	7·306	8·352
2⅝	2·193	2·740	3·288	3·836	4·386	5·479	6·576	7·671	8·772
2¾	2·297	2·870	3·444	4·018	4·594	5·740	6·888	8·036	9·188
2⅞	2·402	3·001	3·601	4·201	4·804	6·001	7·202	8·402	9·608
3	2·506	3·131	3·758	4·384	5·012	6·262	7·516	8·767	10·024
3¼	2·715	3·392	4·071	4·749	5·430	6·784	8·142	9·498	10·860
3½	2·923	3·653	4·384	5·114	5·846	7·306	8·768	10·228	11·692
3¾	3·132	3·914	4·697	5·479	6·264	7·828	9·394	10·959	12·528
4	3·341	4·175	5·010	5·845	6·682	8·350	10·020	11·690	13·364
4¼	3·549	4·436	5·323	6·210	7·098	8·871	10·646	12·421	14·196
4½	3·758	4·697	5·636	6·575	7·516	9·393	11·272	13·151	15·032
4¾	3·966	4·958	5·949	6·941	7·932	9·915	11·898	13·881	15·864
5	4·175	5·219	6·263	7·306	8·350	10·437	12·526	14·612	16·700
5¼	4·384	5·479	6·576	7·671	8·768	10·958	13·152	15·343	17·536
5½	4·593	5·741	6·889	8·037	9·186	11·480	13·778	16·073	18·372
5¾	4·801	6·001	7·202	8·402	9·602	12·002	14·404	16·804	19·204
6	5·010	6·262	7·515	8·767	10·020	12·524	15·030	17·535	20·042

ROUND BAR IRON.

Weight of a Lineal Foot in lbs.

Diameter in Inches.	Weight in lbs.	Diameter in Inches.	Weight in lbs.	Diameter in Inches.	Weight in lbs.	Diameter in Inches.	Weight in lbs.
⅛	·040	1⅝	6·870	3⅛	25·400	4⅝	55·640
¼	·163	1¾	7·970	3¼	27·475	4¾	58·688
⅜	·363	1⅞	9·150	3⅜	29·625	4⅞	61·820
½	·650	2	10·406	3½	31·870	5	65·040
⅝	1·006	2⅛	11·750	3⅝	34·175	5⅛	68·330
¾	1·456	2¼	13·106	3¾	36·575	5¼	71·700
⅞	1·990	2⅜	14·670	3⅞	39·056	5⅜	75·150
1	2·590	2½	16·256	4	41·620	5½	78·700
1⅛	3·300	2⅝	17·925	4⅛	44·260	5⅝	82·300
1¼	4·070	2¾	19·600	4¼	46·990	5¾	86·006
1⅜	4·920	2⅞	21·500	4⅜	49·790	5⅞	89·800
1½	5·860	3	23·406	4½	52·675	6	93·650

SQUARE BAR IRON.

Weight of a Lineal Foot in lbs.

Side in Inches.	Weight in lbs.	Side in Inches.	Weight in lbs.	Side in inches.	Weight in lbs.	Side in inches.	Weight in lbs.
⅛	·050	1⅝	8·75	3⅛	32·35	4⅝	70·85
¼	·206	1¾	10·10	3¼	34·98	4¾	74·80
⅜	·463	1⅞	11·65	3⅜	37·73	4⅞	78·94
½	·825	2	13·27	3½	40·56	5	83·00
⅝	1·320	2⅛	14·96	3⅝	43·52	5⅛	87·20
¾	1·852	2¼	16·80	3¾	46·57	5¼	91·40
⅞	2·537	2⅜	18·69	3⅞	49·80	5⅜	95·90
1	3·306	2½	20·74	4	53·12	5½	100·43
1⅛	4·200	2⅝	22·82	4⅛	56·50	5⅝	105·06
1¼	5·270	2¾	25·11	4¼	59·88	5¾	109·76
1⅜	6·256	2⅞	27·40	4⅜	63·40	5⅞	114·51
1½	7·460	3	29·88	4½	67·23	6	119·52

SHEET IRON AND STEEL.

Weight of a Superficial Foot in Pounds and Fractions, with Corresponding Number and Thickness of Birmingham Wire Gauge.

No. of Birmingham Wire Gauge.	Thickness in Parts of an Inch. Board of Trade Standard.	Weight per Square Foot in lbs.		No. of Birmingham Wire Gauge.	Thickness in Parts of an Inch. Boardof Trade Standard.	Weight per Square Foot in lbs.	
		Iron.	Steel.			Iron.	Steel.
1	·300	12·00	12·240	19	·041	1·64	1·673
2	·284	11·36	11·587	20	·035	1·40	1·428
3	·260	10·40	10·608	21	·032	1·28	1·306
4	·238	9·52	9·710	22	·028	1·12	1·142
5	·220	8·80	8·976	23	·025	1·00	1·020
6	·203	8·12	8·282	24	·022	0·88	0·898
7	·180	7·20	7·344	25	·020	0·80	0·816
8	·165	6·60	6·732	26	·018	0·72	0·734
9	·148	5·92	6·038	27	·016	0·64	0·653
10	·135	5·40	5·508	28	·014	0·56	0·571
11	·120	4·80	4·896	29	·013	0·52	0·530
12	·109	4·36	4·447	30	·012	0·48	0·490
13	·095	3·80	3·876	31	·010	0·40	0·408
14	·083	3·32	3·386	32	·009	0·36	0·367
15	·072	2·88	2·938	33	·008	0·32	0·326
16	·065	2·60	2·652	34	·007	0·28	0·286
17	·058	2·32	2·366	35	·005	0·20	0·204
18	·050	2·00	2·040	36	·004	0·16	0·163

STEEL.

Weight of One Foot of Round Steel.

Diameter in Inches.	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2
Weight per Foot in lbs.	·167	·376	·669	1·04	1·5	2·05	2·67	3·38	4·18	5·06	6·02	7·07	8·2	9·41	11·71

WEIGHT IN POUNDS OF A SUPERFICIAL FOOT OF IRON, COPPER, AND BRASS.

Thickness by the Birmingham Wire Gauge.	Iron. lbs.	Copper. lbs.	Brass. lbs.	Thickness by the Birmingham Wire Gauge.	Iron. lbs.	Copper. lbs.	Brass. lbs.
1	12·50	14·50	13·75	16	2·50	2·90	2·75
2	12·00	13·90	13·20	17	2·18	2·52	2·40
3	11·00	12·75	12·10	18	1·86	2·15	2·04
4	10·00	11·60	11·00	19	1·70	1·97	1·87
5	8·74	10·10	9·61	20	1·54	1·78	1·69
6	8·12	9·40	8·93	21	1·40	1·62	1·54
7	7·50	8·70	8·25	22	1·25	1·45	1·37
8	6·86	7·90	7·54	23	1·12	1·30	1·23
9	6·24	7·20	6·86	24	1·00	1·16	1·10
10	5·62	6·50	6·18	25	·90	1·04	·99
11	5·00	5·80	5·50	26	·80	·92	·88
12	4·38	5·08	4·81	27	·72	·83	·79
13	3·75	4·34	4·12	28	·64	·74	·70
14	3·12	3·60	3·43	29	·56	·64	·61
15	2·82	3·27	3·10	30	·50	·58	·55

WEIGHT OF A SUPERFICIAL FOOT OF VARIOUS METALS.

Thickness in Inches.	Wrought Iron.	Cast Iron.	Steel.	Copper.	Brass.	Lead.	Zinc.	Thickness in Inches.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
1-16th.	2·526	2·344	2·552	2·891	2·734	3·708	2·344	1-16th.
1-8th.	5·052	4·687	5·104	5·781	5·469	7·417	4·687	1-8th.
3 16ths.	7·578	7·031	7·656	8·672	8·203	11·125	7·031	3-16ths.
1-4th.	10·104	9·375	10·208	11·563	10·938	14·833	9·375	1-4th.
5-16ths	12·630	11·719	12·760	14·453	13·672	18·542	11·719	5-16ths.
3-8ths.	15·156	14·062	15·312	17·344	16·406	22·250	14·062	3-8ths.
7-16ths.	17·682	16·406	17·865	20·234	19·141	25·958	16·406	7-16ths.
1-half.	20·208	18·750	20·417	23·125	21·875	29·667	18·750	1-half.
9-16ths.	22·734	21·094	22·969	26·016	24·609	33·375	21·094	9-16ths.
5-8ths.	25·260	23·437	25·521	28·906	27·344	37·083	23·437	5-8ths.
11-16ths.	27·786	25·718	28·073	31·797	30·078	40·792	25·781	11-16ths.
3-4ths.	30·312	28·125	30·625	34·688	32·813	44·500	28·125	3-4ths.
13-16ths.	32·839	30·469	33·177	37·578	35·547	48·208	30·469	13-16ths.
7-8ths.	35·365	32·812	35·729	40·469	38·281	51·917	32·812	7-8ths.
15-16ths.	37·891	35·156	38·281	43·359	41·016	55·625	35·156	15-16ths.
1	*40·417*	37·500	40·833	46·250	43·750	59·333	37·500	1

WEIGHT IN PARTS OF A POUND OF A SPHERE 1 IN. DIAM. OF VARIOUS METALS.

Brass. Cast.	Bronze.	Copper. Hammered.	Iron. Cast.	Iron. Wrought.	Steel.	Lead.	Tin.	Zinc.
·156	·159	·167	·135	·145	·147	·214	·139	·133

HOOP IRON.

Weight of 10 *Lineal Feet.*

Width in Inches and Parts.	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½	1¾	2
No. of Gauge.	21	20	19	18	17	16	15	14	13	12
Weight in lbs. and Decimal Parts.	·685	·885	1·24	1·60	2·05	2·73	3·40	3·72	4·72	6·06

TAPER ANGLE-IRON, OF EQUAL SIDES.

Length of Sides. in Inches.	Thickness of Edges.	Thickness of Root.	Weight of One Lineal Foot in lbs. and Decimal Parts.
4	½ in.	⅝ in.	14·0
3	½	⅝	10·375
2¾	7/16	9/16	8·25
2½	⅜	½	6·5
2¼	5/16 full	7/16	5·0
2	¼ full	5/16 full	3·875
1¾	¼	5/16	3·25
1½	¼ bare	5/16 bare	2·625

TAPER T-IRON.

Width of Top Table in Inches.	Total Depth in Inches.	Thickness of Top Table at Root.	Thickness of Top Table at Edges.	Uniform thickness of Rib.	Weight of One Lineal Foot in lbs.
3	3¼	½ in.	⅜ in.	7/16 in.	8·0
3	2⅝	7/16	⅜	½	8·0
2	3	7/16	5/16	5/16	5·25
2½	2½	⅜	¼	½ full	6·5
2	1½	⅜	5/16	⅜	3·5
2	1½	5/16	¼	¼	2·875

WEIGHT OF CORRUGATED IRON ROOFING.

B.W. Gauge.	Size of Sheets.	Per Square.	Super. Feet per Ton.
16	6 feet × 2 feet to 8 feet × 3 feet	3⅛ cwt.	800
18	6 ,, × 2 ,, 8 ,, × 3 ,,	2¼ ,,	1000
20	6 ,, × 2 ,, 8 ,, × 3 ,,	1¾ ,,	1250
22	6 ,, × 2 ,, 7 ,, × 2½ ,,	1½ ,,	1550
24	6 ,, × 2 ,, 7 ,, × 2½ ,,	1¼ ,,	1880
26	6 ,, × 2 ,, 7 ,, × 2½ ,,	1 ,,	2170

WEIGHT IN POUNDS OF NUTS AND BOLT-HEADS.

Diameter of Bolt in Inches.	¼	⅜	½	⅝	¾	⅞	1	1¼	1½	1¾	2	2½	3
Weight of Hexagon Nut and Head.	·017	·057	·128	·267	·430	·730	1·10	2·14	3·77	5·62	8·75	17·2	28·8
Weight of Square Nut and Head.	·021	·070	·164	·321	·553	·882	1·31	2·56	4·42	7·00	10·50	21·0	36·4

WHITWORTH'S SCREWS WITH ANGULAR THREADS.

Diameter in Inches.	Number of Threads per Inch.	Diameter in Inches.	Number of Threads per Inch.	Diameter in Inches.	Number of Threads per Inch.
⅛	40	1⅜	6	3	3½
3/16	24	1½	6	3¼	3¼
¼	20	1⅝	5	3½	3¼
5/16	18	1¾	5	3¾	3
⅜	16	1⅞	4½	4	3
7/16	14	2	4½	4¼	2⅞
½	12	2⅛	4½	4½	2⅞
⅝	11	2¼	4	4¾	2¾
¾	10	2⅜	4	5	2¾
⅞	9	2½	4	5¼	2⅝
1	8	2⅝	4	5½	2⅝
1⅛	7	2¾	3½	5¾	2½
1¼	7	2⅞	3½	6	2½

Angle of threads, 55° in every instance.

The threads do not intersect at their sides, but are rounded off one-sixth both at top and bottom, making their depth equal to two-thirds of the pitch.

The number of threads to the inch in square-threaded screws is generally half the number of those in angular-threaded screws, and the depth equal to the space between the threads.

TABLE

Showing the Lineal Expansion of Metals produced by Raising their Temperature from 32° to 212° Fahr.

Zinc	1 part in 322	Gold	1 part in 682
Platinum	„ 351	Bismuth	„ 719
Tin (pure)	„ 403	Iron	„ 812
Tin (impure) . . .	„ 500	Antimony	„ 923
Silver	„ 524	Palladium	„ 1000
Copper	„ 581	Platinum	„ 1100
Brass	„ 584	Flint Glass	„ 1248

TABLE

Showing the Relative Power of Metals for Conducting Heat

Gold	1000	Iron	374·3
Silver	973	Zinc	363
Copper	898·2	Tin	303·9
Platinum	381	Lead	179·6

WEIGHT OF CHAINS.

iameter of Link in Inches.	Weight per Lineal Foot in lbs.	Diameter of Link in Inches.	Weight per Lineal Foot in lbs.	Diameter of Link in Inches.	Weight per Lineal Foot in lbs.
$\frac{3}{16}$	·33	$\frac{3}{4}$	5·33	$1\frac{5}{16}$	16·00
$\frac{1}{4}$	·63	$\frac{13}{16}$	6·16	$1\frac{3}{8}$	17·66
$\frac{5}{16}$	·91	$\frac{7}{8}$	7·16	$1\frac{7}{16}$	19·25
$\frac{3}{8}$	1·33	$\frac{15}{16}$	8·16	$1\frac{1}{2}$	20·83
$\frac{7}{16}$	1·50	1	9·33	$1\frac{5}{8}$	24·17
$\frac{1}{2}$	2·33	$1\frac{1}{16}$	10·50	$1\frac{3}{4}$	28·33
$\frac{9}{16}$	3·00	$1\frac{1}{8}$	11·83	$1\frac{7}{8}$	32·50
$\frac{5}{8}$	3·67	$1\frac{3}{16}$	13·16	2	33·33
$\frac{11}{16}$	4·50	$1\frac{1}{4}$	14·50		

To find the Safe Load on Chains.

$$\frac{(\text{Diam. of link in eighths of an inch})^2}{8} = \text{safe load in tons.}$$

$$\sqrt{}(8 \times \text{weight to be raised}) = \text{diam. of link in eighths of inch.}$$

WEIGHT AND STRENGTH OF ROUND ROPES OF HEMP AND WIRE.

Hemp.			Iron Wire.			Steel Wire.		
rth or reum- ence in ches.	Weight per Fathom of Six Feet, in lbs.	Breaking Weight in Tons.	Girth or Circum- ference in Inches.	Weight per Fathom of Six Feet, in lbs.	Breaking Weight in Tons.	Girth or Circum- ference in Inches.	Weight per Fathom of Six Feet, in lbs.	Breaking Weight in Tons.
$\frac{3}{4}$	·15	$\frac{1}{5}$	$\frac{3}{4}$	·56	$\frac{7}{8}$	1	1	$2\frac{1}{2}$
1	·26	$\frac{1}{3}$	1	1	$1\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$3\frac{3}{4}$
$1\frac{1}{2}$	·59	$\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$3\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$4\frac{3}{4}$
2	1·04	$\frac{4}{5}$	$1\frac{5}{8}$	2	4	$1\frac{1}{2}$	$1\frac{3}{4}$	$5\frac{1}{2}$
$2\frac{1}{2}$	1·70	$1\frac{1}{4}$	$1\frac{3}{4}$	$2\frac{1}{2}$	$4\frac{1}{2}$	$1\frac{5}{8}$	2	$6\frac{1}{2}$
$2\frac{3}{4}$	2·00	$1\frac{1}{2}$	$1\frac{7}{8}$	3	$5\frac{1}{4}$	$1\frac{3}{4}$	$2\frac{1}{4}$	$7\frac{1}{2}$
3	2·34	$1\frac{4}{5}$	2	$3\frac{1}{2}$	6	$1\frac{7}{8}$	$2\frac{3}{4}$	$8\frac{3}{4}$
$3\frac{1}{2}$	3·19	$2\frac{1}{2}$	$2\frac{1}{8}$	4	$6\frac{3}{4}$	2	$3\frac{1}{4}$	10
$3\frac{3}{4}$	3·66	$2\frac{4}{5}$	$2\frac{1}{4}$	$4\frac{1}{2}$	$7\frac{1}{2}$	$2\frac{1}{8}$	$3\frac{3}{4}$	$11\frac{1}{4}$
4	4·16	$3\frac{1}{5}$	$2\frac{3}{8}$	5	$8\frac{1}{4}$	$2\frac{1}{4}$	$4\frac{1}{4}$	$12\frac{1}{2}$
$4\frac{1}{2}$	5·27	4	$2\frac{1}{2}$	$5\frac{1}{2}$	$9\frac{1}{4}$	$2\frac{3}{8}$	$4\frac{3}{4}$	14
5	6·50	5	$2\frac{5}{8}$	6	$10\frac{1}{4}$	$2\frac{1}{2}$	$5\frac{1}{4}$	$15\frac{1}{2}$
$5\frac{1}{2}$	7·86	6	$2\frac{3}{4}$	$6\frac{1}{2}$	$11\frac{1}{4}$	$2\frac{5}{8}$	$5\frac{3}{4}$	$17\frac{1}{4}$
6	9·36	$7\frac{1}{4}$	$2\frac{7}{8}$	7	$12\frac{1}{4}$	$2\frac{3}{4}$	$6\frac{1}{4}$	19
$6\frac{1}{2}$	11·00	$8\frac{1}{2}$	3	$7\frac{1}{2}$	$13\frac{1}{4}$	$2\frac{7}{8}$	$6\frac{3}{4}$	$20\frac{1}{2}$
7	12·74	$9\frac{3}{4}$	$3\frac{1}{8}$	8	$14\frac{1}{2}$	3	$7\frac{1}{4}$	$22\frac{1}{2}$
$7\frac{1}{2}$	14·63	$11\frac{1}{4}$	$3\frac{1}{4}$	$8\frac{1}{2}$	16	$3\frac{1}{8}$	$7\frac{1}{2}$	$24\frac{1}{2}$
8	16·64	$12\frac{3}{4}$	$3\frac{3}{8}$	9	17	$3\frac{1}{4}$	8	$26\frac{1}{2}$
$8\frac{1}{2}$	18·78	$14\frac{1}{2}$	$3\frac{1}{2}$	10	$18\frac{1}{2}$	$3\frac{3}{8}$	9	$28\frac{1}{2}$
9	21·06	$16\frac{1}{4}$	$3\frac{5}{8}$	11	$19\frac{3}{4}$	$3\frac{1}{2}$	10	$30\frac{1}{2}$
$9\frac{1}{2}$	23·46	18	$3\frac{3}{4}$	12	21	$3\frac{3}{4}$	12	35
10	26·00	20	$3\frac{7}{8}$	13	$22\frac{1}{2}$	4	15	40
$10\frac{1}{2}$	28·66	22	4	14	24			
11	31·46	$24\frac{1}{4}$	$4\frac{1}{4}$	15	27			
$11\frac{1}{2}$	34·38	$26\frac{1}{2}$	$4\frac{3}{8}$	16	$28\frac{3}{4}$			
12	37·44	29	$4\frac{1}{2}$	18	$30\frac{1}{4}$			
			$4\frac{5}{8}$	20	32			
			5	25	38			
			$5\frac{1}{2}$	32	$45\frac{1}{2}$			
			6	38	54			

To find the Breaking Weight of Round Ropes of Hemp, Iron Wir and Steel Wire.

Hemp $\frac{(\text{circum. ins.})^2}{5}$ = breaking weight in tons.

Iron wire $(\text{circum. ins.})^2 \times 1{\cdot}5$ = breaking weight in tons.

Steel wire $(\text{circum. ins.})^2 \times 2{\cdot}5$ = breaking weight in tons.

Factor of safety for hemp, iron, and steel ropes = $\frac{1}{6}$.

To find the Weight of Hemp Ropes.

$(\text{Circum. ins.})^2 \times {\cdot}26$ = weight in lbs. per fathom.

TABLE

Of the Velocity and Force of the Wind.

Miles per Hour.	Feet per Second.	Pressure in lbs. per Square Foot.	Description.
1	1·47	·005	Hardly perceptibl
2	2·93	·020	Just perceptible.
3	4·4	·044	
4	5·87	·079	Gentle breeze.
5	7·33	·123	
10	14·67	·492	Pleasant breeze.
15	22·	1·107	
20	29·34	1·968	Brisk gale.
25	36·67	3·075	
30	44·01	4·429	High wind.
35	51·34	6·027	
40	58·68	7·873	Very high wind.
45	66·01	9·963	
50	73·35	12·300	Storm or tempest.
60	88·02	17·713	Great storm.
70	102·71	24·153	
80	117·36	31·490	Hurricane.
100	146·7	49·200	

The pressure or force of the wind is as the square of its velocity.

The square of the velocity of the wind in feet per second × ·00 = pressure in lbs. per square foot.

The resistance of a sphere is about one-fourth of that of its grea circle.

SPECIFIC GRAVITY AND WEIGHT OF VARIOUS SUBSTANCES.

Name of Substance.	Specific Gravity and Weight per Cub. Ft. in Ounces.	Weight per Cub. Foot in lbs. Avoirdupois.
Alcohol, pure	790	49·38
Ash (timber)	752	47
Asphalt, prepared	2,496	156
Basalt	2,992	187
Bath stone	1,792	112
Beech	688	43
Birch	704	44
Bitumen	992	62
Boxwood	960	60
Brass, cast	8,240	515
„ wire	8,480	530
Brick	2,080	130
Brickwork	1,792	112
Cement, Portland	1,424	89
„ Roman	960	60
Chalk	2,368	148
Charcoal, oak	336	21
Clay	1,920	120
„ puddle	2,560	160
Coal, anthracite, solid	1,280	80
„ bituminous, „	1,200	75
„ cannel, Scotch	1,248	78
„ „ Wigan	1,280	80
„ „ N'castle	1,312	82
„ stored in usual way	832	52
Coke from coking-ovens	800	50
„ from gas works, slaked	560	35
„ from gas works, unslaked	448	28
Concrete	1,920	120
Copper, cast	8,640	540
„ sheet and wire	8,800	550
Cork	240	15
Earth, loam	1,600	100
Ebony	1,200	75
Elm	560	35
Fir, red pine & spruce	560	35
„ American	464	29
„ larch	544	34
Flag, Yorkshire	2,288	143
Flint	2,624	164
Freestone	2,240	140
Glass, crown	2,496	156
„ plate	2,880	180
„ flint	2,992	187
Gold, pure	19,360	1210
„ standard	17,728	1108
Granite	2,688	168
Gravel	1,840	115
Grindstone	2,096	131
Gun metal	8,784	549
Gypsum	2,304	144
Ice	908	56·75
Iron, cast	7,168	448
Iron, wrought	7,680	480
Lead	11,392	712
„ white	3,168	198
Limestone, lias	2,496	156
„ magnesian	2,848	178
Lime, quick	864	54
Mahogany, Honduras	640	40
„ Spanish	720	45
Maple	784	49
Marble	2,720	170
Marl	1,728	108
Masonry	2,240	140
Mercury	13,584	849
Mortar	1,760	110
Mud	1,600	100
Naphtha	848	53
Oak, English	800	50
„ American, red	864	54
Oil, linseed	944	59
„ olive	912	57
„ whale (train)	928	58
„ sperm	880	55
„ tallow	896	56
„ colza	912	57
Paving	2,560	160
Peat	1,280	80
Pebble stone	2,704	169
Petroleum	880	55
Pitch	1,152	72
Platinum, pure	19,520	1,220
„ hammered	20,480	1,280
„ wire	20,800	1,300
Portland stone	2,096	131
Quartz	2,640	165
Sand, damp	1,888	118
„ dry	1,440	90
Sandstone	2,528	158
Shale	2,592	162
Shingle	1,520	95
Silver, pure	10,480	655
„ standard	10,528	658
Slate	2,880	180
Snow	128	8
Steel	7,840	490
Sulphur	2,000	125
Sycamore	592	37
Tar	1,040	65
Tile	1,792	112
Tin	7,360	460
Trap	2,720	170
Water, pure	1,000	62·5
„ sea	1,024·8	64·05
Whinstone	2,752	172
Willow	448	28
Yew	800	50
Yorkshire flag	2,288	143
Zinc	7,040	440
Mean of the whole Earth	5,664	354

MISCELLANEOUS ARTICLES.

Bale of flax (Russia)	5 to 6 cwt.
Barrel bulk	5 cubic feet.
Barrel of tar	26½ gallons.
Battens	Boards 7 inches wide.
Bushel of coal	80 lbs.
Bushel of coke	45 lbs.
Cable's length	240 yards.
Cask of black lead	11½ cwt.
Chaldron of coal	25½ „
„ coke	12½ to 15 cwt.
Cord of wood	128 cubic feet.
Deals	Boards 9 inches wide.
Dozen	12 articles.
Faggot of steel	120 lbs.
Fodder of lead	19½ cwt.
Gross	12 dozen.
Hundred of deals	120 in number.
„ nails	120 „
Keel of coals	21 tons 4 cwt.
Load of bricks	500 bricks.
„ inch boards	600 square feet.
„ lime	32 bushels.
„ new hay	19 cwt. 32 lbs.
„ old hay	18 „
„ straw	11 „ 64 „
„ sand	36 bushels.
„ squared timber	50 cubic feet.
„ unhewn „	40 „
„ tiles	1000 tiles.
„ 2-inch planks	300 square feet.
Mat of flax (Dutch)	126 lbs.
Pig of ballast	56 lbs.
Planks	Boards 12 inches wide.
Quire of paper	24 sheets.
Ream of paper	20 quires, or 480 sheets.
Roll of parchment	60 skins.
Sack of coals	224 lbs.
Score	20 articles.
Sheet of paper folded into—	
2 leaves is termed	folio size.
4 „ „	4to, or quarto.
8 „ „	8vo, or octavo.
12 „ „	12mo, or duodecimo.
16 „ „	16mo.
18 „ „	18mo.
24 „ „	24mo.
48 „ „	48mo.
Square of planking	100 superficial feet.
Thousand of nails	1200 nails.
Ton shipping	40 cubic feet.
Truss of old hay	56 lbs.
„ new hay	60 „
„ straw	36 „

OFFICE MEMORANDA.

Books required in the Keeping of a Gas Company's Accounts.

1. Ledger (general).
2. Cash Book (general).
3. Gas Register, or Ledger, sometimes called "The Consumers' Ledger."
4. Mill Register, or Ledger.

   This book is devoted to the accounts of all the largest consumers, such as millowners, and the proprietors of other large establishments of any kind where the consumption of gas is heavy. They are handier classed together by themselves, than mixed up with smaller consumers.
5. Removals Book.

   In this book is kept an account of all changes of residence that have taken place amongst consumers during each quarter, the substitution of meters, and the consumption of gas by temporary consumers, &c. It is a most useful record, and prevents confusion by interlineations in the regular register.
6. Quarterly Summary.

   The several pages in the three foregoing books are added up, and then brought together here, quarterly, in order to ascertain the total consumption, amount due, &c. By means of this book it is easy to compare the totals of the different quarters during a number of years.
7. Journal,

   Containing entries of all goods sold from the works, with the exception of gas. Separate columns should be arranged for "Fittings, &c.," "Residual Products," "Miscellaneous," and "Total." At the end of each quarter the separate amounts of all accounts remaining unpaid are transferred to the
8. Arrears Fittings, &c., Book,

   Which is entered up at the end of every quarter, and shows the amount remaining due (arrears included) for fittings, residual products, and miscellaneous.
9. Daily Receipt (Cash) Book,

   In which is entered the amount of each separate payment made to the company on account of "Gas," "Meter Rents," "Fittings, &c.," "Residual Products," and other miscellaneous items.
10. Stock-Taking Books,

    For taking the quarterly stock of gas consumed through each meter. Two or more are always required, according to the number of consumers. The one used (we will suppose) on Monday is left at the office that night to be entered up into the register, by the clerk, on the day following; and so on alternately.
11. Black Book,

    In which a record of all bad debts is kept.

12. Collector's Book.
    In some cases, checks only are used, with counterfoil.
13. Receiving Book,
    In which all delivery notes for goods received by the company are copied daily. The regular invoice, when received, is checked by this book.
14. Wages and Time Book,
    Containing, in separate columns, a daily account of the number of hours worked by each man, the kind of work, and the place where employed, with the amount due as wages at the end of each week or fortnight, as the case may be.
15. Stores Book, A.
16. Stores Book, B.
    In the one is kept a record of goods *sold* out of stock, and in the other of goods *used* out of stock for *repairs and extensions of plant*. The one may be said to relate to *revenue*, the other chiefly to *capital*.
17. Stores Ledger,
    Into which the entries in the previous two books are posted to the *credit* of the several accounts (such as "Meters," "Lead Pipe," "Wrought-iron Fittings," &c.), and the items from the several invoices are posted to the *debit* of the several accounts. At the end of each half year the balance of each account represents the stock on hand. This latter is proved to be correct or otherwise by the result of the actual stock-taking.
18. Carbonizing Book—Daily and Weekly Statements,
    Containing a record of the state of the station-meter taken twice in the 24 hours (in large works, the state of the meter is recorded every hour); the quantity of coal and cannel used daily, the production of gas per ton, and the total daily production; the number of benches at work, stokers, &c. Each page serves for a week, and is then added up; an additional line is left at the foot of the page, on which is entered the particulars of the corresponding week of the previous year.
19. Public Lamp Register,
    Gives particulars of the number of lamps lighted each night; the hours of lighting and extinguishing; the hours burning per lamp, the total hours burning; a column into which the number of hours, weekly, can be added, and another for remarks.
20. Test Register,
    For noting the results of the different tests of the illuminating power and purity of the gas.
21. Shareholders' Register and Address Book.
22. Seal Register and Dividend List.
23. Register of Calls.
24. Register of Transfers.
25. Transfer Certificate Book,
    Containing certificates of the registration of shares, to be torn out, *leaving* counterfoil behind.

6. Invoice Book,
   With blank leaves, into which are gummed all invoices for goods received.
7. Minute Book.
   A lettered index at the beginning of this book is handy.

A few other account-books of a less important character may be seful, but the above may be said to be almost indispensable in a well-egulated gas company.

Discount for Early Payment of Gas Bills.

The custom of allowing discount to consumers on gas bills paid ither during the first month after the expiration of a quarter, or rithin a period of 21 or 30 days from the date of the delivery of the ccount, is becoming very general amongst gas companies.

The most common allowance is at the rate of 10 per cent. on the mount due for gas consumed (excluding the meter-rent), but the remium varies throughout the country from 5 to 20 per cent., some ompanies adopting a graduated scale of discounts according to the uarterly consumption.

The practice, wherever adopted, has been found highly beneficial, aving labour in collecting, and reducing the percentage of bad debts.

FORMS.

Renouncement of Proposed New Issue on the Transfer of Old Shares.

I, John Thompson, of Tipping Street, Newcastle, hereby renounce ay right to any of the new Shares about to be issued by the ——— as Company, in favour of William Jones, of Broad Street, Manchester.

(Signed) John Thompson,
Jan. 1, 18—

To the Secretary
of the ——— Gas Company.

Renunciation of Shares newly Allotted.

I, John Wilson, of Birmingham, being the holder [*or* proprietor] of ——— Shares in the ——— Gas Company, do hereby renounce the ame to and in favour of William Jackson of Bristol. And I the said Villiam Jackson, hereby agree to accept and take the said Shares, ubject to the conditions on which they are allotted. Dated this ——— ay of ———, One thousand eight hundred and ———.

Signed by the said
John Wilson in the
presence of
(*Here witness signs*).

John Wilson.

Signed by the said
William Jackson in
the presence of
(*Here witness signs*).

William Jackson.

Declaration for Loss of Sealed Share Certificates.

I, ———, of ———, do hereby solemnly and sincerely declare that I am possessed of and entitled to ——— in the ——— Company, ———, and that the said ——— are *bonâ fide* my property, and that they are not pledged or assigned to any person or persons whomsoever for money advanced thereon, or for any consideration whatever. And I further declare that I have made diligent search for the ——, and can nowhere find the same. And I make this solemn declaration conscientiously believing the same to be true, and by virtue of the provisions of an Act made and passed in the 5th and 6th years of the reign of His late Majesty King William the Fourth, intituled "An Act to repeal an Act of the present Session of Parliament, intituled 'An Act for the more effectual abolition of Oaths and Affirmations taken and made in various departments of the State, and to substitute Declarations in lieu thereof,' and for the more entire suppression of voluntary and extra judicial Oaths and Affidavits, and to make other provisions for the abolition of unnecessary Oaths."

Declared at ——, this —— day of ———, One thousand eight hundred and ——, before me.

[The above Declaration is to be made before a Commissioner to administer Oaths in Chancery in England. Any person making a false Declaration is declared guilty of a misdemeanour.]

Indemnity for Loss of Share Certificates or Dividend Warrant.

——— Company.

Whereas ———, in the company called the ———, numbered ——, being the property of ———, the undersigned, h— by accident been lost or destroyed, and the said company have consented to give ———, on being indemnified for so doing. Now, in consideration of the said company so granting to me, the said ———, a ———, we the undersigned ——— and ——— do hereby severally and respectively undertake and agree to save harmless and keep indemnified the Directors for the time being of the said company of and from all losses, damages, and expenses which they, any or either of them, may sustain, incur, or be put unto, for or in consequence of their so granting such new ———; and also from and against all claim or claims to be at any time hereafter made upon the said company for or in respect of the original ——— by any person or persons whomsoever.

Dated this —— day of ———, One thousand eight hundred and ——.

Declaration of Transmission of Shares (from wife to husband) in consequence of Marriage.

I, John Smith, of ——— in the county of ———, do hereby solemnly declare that on the —— day of ———, One thousand eight hundred and ——, I was married at ——— church, ———, in the parish of ———, in the county of ———, to Mary Baker, of ——— aforesaid, *———, and that the accompanying document is a true r of or extract from the marriage register of ——— church, ———, that the said Mary Baker referred to in the above-named register le same person whose name now appears in the books as a share-er in the ——— Gas Company, and that prior to the celebration he aforesaid marriage neither any deed of settlement or any other l or document was prepared or executed upon any trusts affecting pecuniary interest or otherwise of either myself or the said y Baker. And I do make this solemn declaration conscientiously eving the same to be true, and by virtue of the provisions of an made and passed in the 5th and 6th years in the reign of His late esty King William the Fourth, intituled "An Act to repeal an Act he present Session of Parliament, intituled 'An Act for the more ctual abolition of Oaths and Affirmations taken and made in various rtments of the State, and to substitute declarations in lieu there-and for the more entire suppression of voluntary and extra judicial hs and Affidavits, and to make other provisions for the abolition of ecessary Oaths."

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* Spinster or Widow, as the case may be.

eclared at ——, this —— day of ——, One thousand eight hundred ——, before me.

[The above Declaration is to be made before a Commissioner to ninister Oaths in Chancery in England.]

Authority to Pay Dividends.

——— Company,
——— 18—

Payment of Dividends.

the undersigned, ———, of ———, being a shareholder of and he undertaking called the ——— Company, do hereby request all Dividends and Interest due to me on the Stock or Shares now stered, or that may hereafter be registered in my name may be paid ———, of ———, until further notice, whose receipt shall be a icient discharge to the Company for the payment of the same.

Signature_______________

Date_______________

Certificate Showing that Income-Tax has been Deducted.

his is to certify that on paying to John Brown the sum of £45, ig the amount of one year's Dividend (*or*, one half year's Dividend, he case may be) on Shares (*or* Stock) to December 31st, 18——, I ucted for Income-Tax the sum of 18s. 9d.

Pro the A——— B——— Gas Company,
WILLIAM JONES,
Secretary.

Form of Proxy.

. B., one of the proprietors of "The ——— Company," doth eby appoint C. D., of ———, to be the proxy of the said A. B., [illegible] absence to vote in his name upon any matter relating to the [illegible] taking proposed at the meeting of the proprietors of the said Company, to be held on the —— day of —— next, in such manner as he the said C. D. doth think proper. In witness whereof the said A. B. hath hereunto set his hand [*or, if a corporation, say*, the common seal of the corporation], the —— day of ——, One thousand eight hundred and ——.

TERMS FOR LEASES, ETC.

England and Ireland.		*Scotland.*	
Lady Day	March 25th.	Candlemas	Feb. 2nd.
Midsummer	June 24th.	Whitsunday	May 15th.
Michaelmas	Sept. 29th.	Lammas	August 1st.
Christmas	Dec. 25th.	Martinmas	Nov. 11th.

When a Scottish term falls on Sunday the Monday following is considered term day.

LAW TERMS.

England and Ireland.

Hilary or Lent	Begins,	Jan. 11th	Ends,	Jan. 31st.
Easter	,,	April 15th	,,	May 8th.
Trinity	,,	May 22nd	,,	June 12th.
Michaelmas	,,	Nov. 2nd	,,	Nov 25th.

Scotland.

Candlemas	Begins,	Jan 15th	Ends	Feb. 3rd.
Whitsunday	,,	May 12th	,,	June 2nd.
Lammas	,,	June 17th	,,	July 5th.
Martinmas	,,	Nov. 24th	,,	Dec. 20th.

STRUCTURAL AND COMMERCIAL VALUE.

The term "Structural Value" has reference to the amount of capital expended upon works in their construction.

"Commercial Value" is the value of the net annual average profits, reckoned on a number of years, which a firm or company can make by the use of their works.

SIZES OF DRAWING PAPER.

	Ft.	In.		Ft.	In.		Ft.	In.		Ft.	In.
Antiquarian . .	4	4	×	2	7	Double Crown . .	3	6	×	1	8
,, extra	4	8	×	3	4	Imperial	2	6	×	1	10
Double elephant .	3	4	×	2	3	Super royal . . .	2	3	×	1	7
Atlas	2	10	×	2	2	Royal	2	0	×	1	7
Columbia. . . .	2	10	×	1	11	Medium	1	10	×	1	5
Elephant. . . .	2	3¾	×	1	10½	Demy	1	8	×	1	3

TABLE OF COLOURS

Used in Mechanical and Architectural Drawing.

Work.	Colour.
Brickwork in plan or section . .	Carmine or crimson lake.
Brickwork in elevation	Venetian red or crimson lake mixed with burnt sienna.
Brickwork to be removed by alterations.	Burnt umber.
Concrete works	Sepia with darker markings.
Clay	Burnt umber.
Earth	Burnt umber.
Flintwork	Prussian blue.
Granite	Purple madder or pale Indian ink.
Stone generally	Yellow ochre or pale sepia.
Slate	Indigo and lake or Prussian blue.
English timber (oak excepted). .	Raw sienna.
Oak	Burnt sienna or Vandyke brown.
Fir and other light timber . . .	Indian yellow or raw sienna.
Mahogany	Indian red.
Cast-iron	Payne's grey or neutral tint.
Wrought-iron.	Prussian blue.
Steel, bright	Indigo with a little lake.
Brass	Gamboge or Roman ochre.
Gun metal	Dark cadmium.
Lead	Pale Indian ink, tinged with Indigo.
Meadow land	Hooker's green.
Sky effects	Cobalt blue.

The presence of any slight greasiness, preventing the laying on of the colours evenly, may be counteracted in its effects by dissolving a little prepared ox-gall in the water with which the colours are mixed. The brush should always be used in mixing colours, the latter being rubbed in separate divisions of the slab.

EPITOME OF MENSURATION.

Of the Circle, Cylinder, and Sphere.

The areas of circles are to each other as the squares of their diameters.

The diameter of a circle being 1, its circumference equals 3·1416.

The diameter of a circle is equal to ·31831 of its circumference.

The square of the diameter of a circle being 1, its area equals ·7854.

The internal circumference of a cylinder multiplied by its length or height equals its concave surface.

The area of the end of a cylinder multiplied by its length equals its solid contents.

The area of the internal diameter of a cylinder multiplied by its depth equals its cubical capacity.

The square of the diameter of a sphere multiplied by 3·1416 equals its convex surface.

The cube of the diameter of a sphere multiplied by ·5236 equals its solid contents.

The capacity of a cylinder 1 foot in diameter and 1 foot in length equals 4·895 imperial gallons.

The capacity of a cylinder 1 inch in diameter and 1 foot in length equals ·034 of an imperial gallon.

The capacity of a cylinder 1 inch in diameter and 1 inch in length equals ·002832 of an imperial gallon. Hence—

The capacity of any other cylinder in imperial gallons is obtained by multiplying the square of its diameter by its length, and by the number of imperial gallons contained in the unity of its measurement.

The capacity of a sphere 1 foot in diameter equals 3·263 imperial gallons.

The capacity of a sphere 1 inch in diameter equals ·001888 of an imperial gallon. Hence—

The capacity of any other sphere in imperial gallons is obtained by multiplying the cube of its diameter by the number of imperial gallons contained in the unity of its measurement.

Of the Square, Rectangle, and Cube.

The side of a square equals the square root of its area.

The area of a square equals the square of one of its sides.

The diagonal of a square equals the square root of twice the square of its side.

The side of a square is equal to the square root of half the square of its diagonal.

The side of a square equal to the diagonal of a given square contains double the area of the given square.

The area of a rectangle equals its length multiplied by its breadth.

The length of a rectangle equals the area divided by the breadth; or the breadth equals the area divided by the length.

The side or end of a rectangle equals the square root of the sum of *the diagonal* and opposite side to that required, multiplied by their *difference.*

The diagonal in a rectangle equals the square root of the sum of the squares of the base and perpendicular.

The solidity of a cube equals the area of one of its sides multiplied by the length or breadth of one of its sides.

The length or breadth of a side of a cube equals the cube root of its solidity.

The capacity of a 12-inch cube equals 6·232 imperial gallons.

Of Triangles and Polygons.

The sum of the squares of the two given sides of a right-angled triangle is equal to the square of the hypotenuse.

The difference between the squares of the hypotenuse and given side of a right-angled triangle is equal to the square of the required side.

The area of a triangle equals half the product of the base multiplied by the perpendicular height.

The side of any regular polygon multiplied by its apothegm, or perpendicular, and by the number of its sides, equals twice the area.

Of Ellipses, Cones, and Frustums.

The square root of half the sum of the squares of the two diameters of an ellipse, multiplied by 3·1416, equals its circumference.

The product of the two axes of an ellipse, multiplied by ·7854, equals its area.

The solidity of a cone equals one-third of the product of its base multiplied by its altitude, or height.

The squares of the diameters of the two ends of the frustum of a cone added to the product of the two diameters, and that sum multiplied by its height and by ·2618, equals its solidity.

ARITHMETICAL AND ALGEBRAICAL SIGNS.

$=$ The sign of Equality, and signifies *equal to*, as 2 added to $3 = 5$.
$+$ „ Addition „ *plus*, or *more*, as $4 + 6 = 10$.
$-$ „ Subtraction „ *minus*, or *less*, as $6 - 4 = 2$.
$\times$ „ Multiplication „ *multiplied by*, as $5 \times 3 = 15$.
$\div$ „ Division „ *divided by*, as $8 \div 4 = 2$, or $\frac{8}{4} = 2$.
: :: : „ Proportion, : signifies *is to*, :: signifies *so is*. Thus, 2 : 3 :: 4 : 6 signifies that as 2 is to 3 so is 4 to 6.

Evolution, or the Extraction of Roots.

$\sqrt{}$ The sign of the Square Root (termed the Radical sign), as $\sqrt{16} = 4$, *i.e.*, the square root of 16 is equal to 4.
$\sqrt[3]{}$ „ Cube Root, as $\sqrt[3]{64} = 4$, *i.e.*, the cube root of 64 is equal to 4.
$\sqrt[4]{}$ „ Bi-quadrate, or fourth Root, as $\sqrt[4]{16} = 2$.

Involution, or the raising of Powers.

4^2 signifies to be squared, as $4^2 = 16$. The small figure is termed the Index or Exponent.

4^3 „ to be cubed, as $4^3 = 64$.

—— A vinculum placed over two or more figures, thus $\overline{3+5}$, signifies that they are to be taken as one quantity. Thus:

$\overline{3+5} \times 4 = 32$, signifies that 3 plus 5 multiplied by 4 = 32, and

$\sqrt{5^2 - 3^2} = 4$, signifies that 5 squared, minus 3 squared, and the square root of the remainder = 4, and

$\sqrt[3]{\frac{20 \times 12}{30}} = 2$, signifies that 20 multiplied by 12, divided by 30, and the cube root of the quotient = 2, and

$\frac{\overline{24 \times 6} + \overline{12 \times 3} \times 4}{12} = 60$ signifies that 24 multiplied by 6, and 12 multiplied by 3, added together, multiplied by 4 and divided by 12, the quotient = 60.

[ ] () Brackets; *e.g.*, $12 - [3 + (4 \times 2)] = 1$, signifies that the product of 4, multiplied by 2, added to 3, and the total subtracted from 12, leaves 1.

∴ is used to signify the word *therefore*.

∵ is used to signify the word *because*, or *since*.

? is used in the Chain Rule to signify *how many*.

APPROXIMATE MULTIPLIERS FOR FACILITATING CALCULATIONS.

Square inches × ·007 = square feet.
Square feet × ·111 = square yards.
Square yards × ·0002067 = statute acres.
Statute acres × 4840 = square yards.
Square links × ·4356 = square feet.
Square feet × 2·3 = square links.
Square feet × 183·346 = circular inches.
Circular inches × ·00456 = square feet.
Links × ·22 = yards.
Links × ·66 = feet.
Feet × 1·5 = links.
Cubic inches × ·00058 = cubic feet.
Cubic inches × ·0163 = French litres.
Cubic feet × ·037 = cubic yards.
Cubic feet × 2200 = cylindrical inches.
Cylindrical inches × ·0004546 = cubic yards.
Cylindrical feet × ·02909 = cubic yards.
Cubic feet × 6·232 = imperial gallons.
Imperial gallons × ·1604 = cubic feet.
Cubic inches × ·003607 = imperial gallons.
Imperial gallons × 277·3 = cubic inches.
Imperial gallons × 4·543 = French litres.
Cubic feet × ·779 = bushels.

Cubic inches × ·00045 = bushels.
Bushels × ·0476 = cubic yards.
Bushels × 1·284 = cubic feet.
Bushels × 2218·2 = cubic inches.
Lineal feet × ·00019 = statute miles.
Lineal yards × ·0006 = statute miles.
Statute miles × ·869 = mean geographical miles.
Mean geographical miles × 1·151 = statute miles.
Pounds avoirdupois × 7000 = grains.
Grains × ·0001429 = pounds avoirdupois.
Pounds avoirdupois × ·009 = cwts.
Pounds avoirdupois × ·00045 = tons.
Tons × 2240 = pounds avoirdupois.
Tons × 1·016 = tonnes, French.
French tonnes × ·984 = English tons.
Pounds on square inch × 144 = pounds on square foot.
Pounds on square foot × ·007 = pounds on square inch.
Miles per hour × 1·467 = feet per second.
Feet per second × ·682 = miles per hour.
French mètres × 3·281 = English feet.
French litres × ·2201 = imperial gallons.
French hectolitres × 2·7512 = English bushels.
French grammes × ·002205 = pounds avoirdupois.
French kilogrammes × 2·205 = pounds avoirdupois.
Diameter of circle × 3·1416 = circumference.
Circumference of circle × ·31831 = diameter.
Diameter of circle × ·8862 = side of equal square.
Circumference of circle × ·2821 = side of equal square.
Diameter of circle × ·7071 = side of inscribed square.
Circumference of circle × ·2251 = side of inscribed square.
Area of circle × ·6366 = side of inscribed square.
Side of square × 1·128 = diameter of equal circle.
Side of square × 3·545 = circumference of equal circle.
Side of square × 1·414 = diameter of circumscribing circle.
Side of square × 4·443 = circumference of circumscribing circle.
Square of diameter × ·7854 = area of circle.
Square root of area × 1·12837 = diameter of equal circle.
Square of diameter of sphere × 3·1416 = convex surface.
Cube of diameter of sphere × ·5236 = solidity.
Diameter of sphere × ·806 = dimensions of equal cube.
Diameter of sphere × ·6667 = length of equal cylinder.
One atmosphere = 14·7 pounds on square inch.
„ = 2116 pounds on square foot.
„ = 29·922 inches of mercury.
„ = 33·9 feet of water.
Each 1000 cubic feet of coal gas in a holder × 40 = (approximate) weight of gas in pounds.
The atomic weight of an *elementary* gas × ·0691 = its specific gravity.[*]
Half the atomic weight of a *compound* gas or vapour × ·0691 = its specific gravity.

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[*] Exceptions to this rule occur in the case of the vapours of phosphorus and arsenic, whose atomic weights must be doubled, and in those of mercury, zinc, and cadmium, the atomic weights of which must be halved.

EXPLANATORY REMARKS ON THE TABLE OF SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND RECIPROCALS OF NUMBERS.

The *first power* of a number is the number itself before being multiplied; thus, 3.

The *square*, or *second power*, of a number is the number multiplied by itself; thus, 4 × 4 = 16, the square of 4.

The *cube*, or *third power*, of a number is the number multiplied by itself, and the product again multiplied by it; thus, 5 × 5 × 5 = 125, the cube of 5.

The *square root* is that number which, on being multiplied by itself, produces the given number thus, 3 is the square root of nine, because 3 × 3 = 9.

The *cube root* is that number which, on being multiplied by itself, and the product again multiplied by it, produces the given number; thus, 4 is the cube root of 64, because 4 × 4 × 4 = 64.

The *reciprocal* of a number is the quotient obtained by dividing 1 by that number; thus, 1 ÷ 4 = ·25, the reciprocal of 4. The result obtained by using any number as a divisor, or its reciprocal as a multiplier, is the same; thus, 12 ÷ 4 = 3, or 12 × ·25 (·25, the reciprocal of 4) = 3.

It will be seen that whilst the numbers in the second and third columns are the squares and cubes of those in the first, the numbers in the first are the square roots and cube roots of those in the second and third columns. The numbers in the first column are also the squares of the fourth, and the cubes of the fifth columns.

The table may be further utilized as follows to any extent required; take, for intance, the number 16—

Numbers.	Squares.	Cubes.	Reciprocals.
·16	·0256	·004096	6·25
1·6	2·56	4·096	·625
16	256	4096	·0625
160	25600	4096000	·00625

Thus, when the decimal point is removed one place either to the right or left in the numbers of the first column, it must be removed two places in the numbers of the second column, and three places in those of the third column in the same direction, whilst in the reciprocal the point is removed one place in the opposite direction.

TABLE OF SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AND RECIPROCALS OF NUMBERS.

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
1	1	1	1·0000000	1·0000000	1·000000000
2	4	8	1·4142136	1·2599210	·500000000
3	9	27	1·7320508	1·4422496	·333333333
4	16	64	2·0000000	1·5874011	·250000000
5	25	125	2·2360680	1·7099759	·200000000
6	36	216	2·4494897	1·8171206	·166666667
7	49	343	2·6457513	1·9129312	·142857143
8	64	512	2·8284271	2·0000000	·125000000
9	81	729	3·0000000	2·0800837	·111111111
10	100	1000	3·1622777	2·1544347	·100000000
11	121	1331	3·3166248	2·2239801	·090909091
12	144	1728	3·4641016	2·2894286	·083333333
13	169	2197	3·6055513	2·3513347	·076923077
14	196	2744	3·7416574	2·4101422	·071428571
15	225	3375	3·8729833	2·4662121	·066666667
16	256	4096	4·0000000	2·5198421	·062500000
17	289	4913	4·1231056	2·5712816	·058823529
18	324	5832	4·2426407	2·6207414	·055555556
19	361	6859	4·3588989	2·6684016	·052631579
20	400	8000	4·4721360	2·7144177	·050000000
21	441	9261	4·5825757	2·7589243	·047619048
22	484	10648	4·6904158	2·8020393	·045454545
23	529	12167	4·7558315	2·8438670	·043478261
24	576	13824	4·8989795	2·8844991	·041666667
25	625	15625	5·0000000	2·9240177	·040000000
26	676	17576	5·0990195	2·9624960	·038461538
27	729	19683	5·1961524	3·0000000	·037037037
28	784	21952	5·2915026	3·0365889	·035714286
29	841	24389	5·3851648	3·0723168	·034482759
30	900	27000	5·4772256	3·1072325	·033333333
31	961	29791	5·5677644	3·1413806	·032258065
32	1024	32768	5·6568542	3·1748021	·031250000
33	1089	35937	5·7445626	3·2075343	·030303030
34	1156	39304	5·8309519	3·2396118	·029411765
35	1225	42875	5·9160798	3·2710663	·028571429
36	1296	46656	6·0000000	3·3019272	·027777778
37	1369	50653	6·0827625	3·3322218	·027027027
38	1444	54872	6·1644140	3·3619754	·026315789
39	1521	59319	6·2449980	3·3912114	·025641026
40	1600	64000	6·3245553	3·4199519	·025000000
41	1681	68921	6·4031242	3·4482172	·024390244
42	1764	74088	6·4807407	3·4760266	·023809524
43	1849	79507	6·5574385	3·5033981	·023255814
44	1936	85184	6·6332496	3·5303483	·022727273
45	2025	91125	6·7082039	3·5568933	·022222222
46	2116	97336	6·7823300	3·5830479	·021739130
47	2209	103823	6·8556546	3·6088261	·021276600
48	2304	110592	6·9282032	3·6342411	·020833333
49	2401	117649	7·0000000	3·6593057	·020408163
50	2500	125000	7·0710678	3·6840314	·020000000
51	2601	132651	7·1414284	3·7084298	·019607843
52	2704	140608	7·2111026	3·7325111	·019230769
53	2809	148877	7·2801099	3·7562858	·018867925
54	2916	157464	7·3484692	3·7797631	·018518519
55	3025	166375	7·4161985	3·8029525	·018181818
56	3136	175616	7·4833148	3·8258624	·017857143
57	3249	185193	7·5498344	3·8485011	·017543860
58	3364	195112	7·6157731	3·8708766	·017241379
59	3481	205379	7·6811457	3·8929965	·016949153

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots	Reciprocals.
60	3600	216000	7·7459667	3·9148676	·016666667
61	3721	226981	7·8102497	3·9364972	·016393443
62	3844	238328	7·8740079	3·9578915	·016129032
63	3969	250047	7·9372539	3·9790571	·015873016
64	4096	262144	8·0000000	4·0000000	·015625000
65	4225	274625	8·0622577	4·0207256	·015384615
66	4356	287496	8·1240384	4·0412401	·015151515
67	4489	300763	8·1853528	4·0615480	·014925373
68	4624	314432	8·2462113	4·0816551	·014705882
69	4761	328509	8·3066239	4 1015661	·014492754
70	4900	343000	8·3666003	4·1212853	·014285714
71	5041	357911	8·4261498	4·1408178	·014084517
72	5184	373248	8·4852814	4·1601676	·013888889
73	5329	389017	8·5440037	4·1793390	·013698630
74	5476	405224	8·6023253	4·1983364	·013513514
75	5625	421875	8·6602540	4·2171633	·013333333
76	5776	438976	8·7177979	4·2358236	·013157895
77	5929	456533	8·7749644	4·2543210	·012987013
78	6084	474552	8·8317609	4·2726586	·012820513
79	6241	493039	8·8881944	4·2908404	·012658228
80	6400	512000	8·9442719	4·3088695	·012500000
81	6561	531441	9·0000000	4·3267487	·012345679
82	6724	551368	9·0553851	4·3444815	·012195122
83	6889	571787	9·1104336	4·3620707	·012048193
84	7056	592704	9·1651514	4·3795191	·011904762
85	7225	614125	9·2195445	4·3968296	·011764706
86	7396	636056	9·2736185	4·4140049	·011627907
87	7569	658503	9·3273791	4·4310476	·011494253
88	7744	681472	9·3808315	4·4479602	·011363636
89	7921	704969	9·4339811	4·4647451	·011235955
90	8100	729000	9·4868330	4·4814047	·011111111
91	8281	753571	9·5393920	4·4979414	·010989011
92	8464	778688	9·5916630	4·5143574	·010869565
93	8649	804357	9·6436508	4·5306549	·010752688
94	8836	830584	9·6953597	4·5468359	·010638298
95	9025	857375	9·7467943	4·5629026	·010526316
96	9216	884736	9·7979590	4·5788570	·010416667
97	9409	912673	9·8488578	4·5947009	·010309278
98	9604	941192	9·8994949	4·6104363	·010204082
99	9801	970299	9·9498744	4·6260650	·010101010
100	10000	1000000	10·0000000	4·6415888	·010000000
101	10201	1030301	10·0498756	4·6570095	·009900990
102	10404	1061208	10·0995049	4·6723287	·009803922
103	10609	1092727	10·1488916	4·6875482	·009708738
104	10816	1124864	10·1980390	4·7026694	·009615385
105	11025	1157625	10·2469508	4·7176940	·009523810
106	11236	1191016	10·2956301	4·7326235	·009433962
107	11449	1225043	10·3440804	4·7474594	·009345794
108	11664	1259712	10·3923048	4·7622032	·009259259
109	11881	1295029	10·4403065	4·7768562	009174312
110	12100	1331000	10·4880885	4·7914199	·009090909
111	12321	1367631	10·5356538	4·8058995	·009009009
112	12544	1404928	10·5830052	4·8202845	·008928571
113	12769	1442897	10·6301458	4·8345881	·008849558
114	12996	1481544	10·6770783	4·8488076	·008771930
115	13225	1520875	10·7238053	4·8629442	·008695652
116	13456	1560896	10·7703296	4·8769990	·008620690
117	13689	1601613	10·8166538	4·8909732	·008547009
118	13924	1643032	10·8627805	4·9048681	·008474576
119	14161	1685159	10·9087121	4·9186847	·008403361
120	14400	1728000	10·9544512	4·9324242	·008333333
121	14641	1771561	11·0000000	4·9460874	·008264463
122	14884	1815848	11·0453610	4·9596757	·008196721
123	15129	1860867	11·0905365	4·9731898	·008130081

Numbers.	Squares	Cubes.	Square Roots.	Cube Roots.	Reciprocals
124	15376	1906624	11·1355287	4·9866310	·008064516
125	15625	1953125	11·1803399	5·0000000	·008000000
126	15876	2000376	11·2249722	5·0132979	·007936508
127	16129	2048383	11·2694277	5·0265257	·007874016
128	16384	2097152	11·3137085	5·0396842	·007812500
129	16641	2146689	11·3578167	5·0527743	·007751938
130	16900	2197000	11·4017543	5·0657970	·007692308
131	17161	2248091	11·4455231	5·0787531	·007633588
132	17424	2299968	11·4891253	5·0916434	·007575758
133	17689	2352637	11·5325626	5·1044687	·007518797
134	17956	2406104	11·5758369	5·1172299	·007462687
135	18225	2460375	11·6189500	5·1299278	·007407407
136	18496	2515456	11·6619038	5·1425632	·007352941
137	18769	2571353	11·7046999	5·1551367	·007299270
138	19044	2628072	11·7473444	5·1676493	·007246377
139	19321	2685619	11·7898261	5·1801015	·007194245
140	19600	2744000	11·8321596	5·1924941	·007142857
141	19881	2803221	11·8743421	5·2048279	·007092199
142	20164	2863288	11·9163753	5·2171034	·007042254
143	20449	2924207	11·9582607	5·2293215	·006993007
144	20736	2985984	12·0000000	5·2414828	·006944444
145	21025	3048625	12·0415946	5·2535879	·006896552
146	21316	3112136	12·0830460	5·2656374	·006849315
147	21609	3176523	12·1243557	5·2776321	·006802721
148	21904	3241792	12·1655251	5·2895725	·006756757
149	22201	3307949	12·2065556	5·3014592	·006711409
150	22500	3375000	12·2474487	5·3132928	·006666667
151	22801	3442951	12·2882057	5·3250740	·006622517
152	23104	3511808	12·3288280	5·3368033	·006578947
153	23409	3581577	12·3693169	5·3484812	·006535948
154	23716	3652264	12·4096736	5·3601084	·006493506
155	24025	3723875	12·4498996	5·3716854	·006451613
156	24336	3796416	12·4899960	5·3832126	·006410256
157	24649	3869893	12·5299641	5·3946907	·006369427
158	24964	3944312	12·5698051	5·4061202	·006329114
159	25281	4019679	12·6095202	5·4175015	·006289308
160	25600	4096000	12·6491106	5·4288352	·006250000
161	25921	4173281	12·6885775	5·4401218	·006211180
162	26244	4251528	12·7279221	5·4513618	·006172840
163	26569	4330747	12·7671453	5·4625556	·006134969
164	26896	4410944	12·8062485	5·4737037	·006097561
165	27225	4492125	12·8452326	5·4848066	·006060606
166	27556	4574296	12·8840987	5·4958647	·006024096
167	27889	4657463	12·9228480	5·5068784	·005988024
168	28224	4741632	12·9614814	5·5178484	·005952381
169	28561	4826809	13·0000000	5·5287748	·005917160
170	28900	4913000	13·9384048	5·5396583	·005882353
171	29241	5000211	13·0766968	5·5504991	·005847953
172	29584	5088448	13·1148770	5·5612978	·005813953
173	29929	5177717	13·1529464	5·5720546	·005780347
174	30276	5268024	13·1909060	5·5827702	·005747126
175	30625	5359375	13·2287566	5·5934447	·005714286
176	30976	5451776	13·2664992	5·6040787	·005681818
177	31329	5545233	13·3041347	5·6146724	·005649718
178	31684	5639752	13·3416641	5·6252263	·005617978
179	32041	5735339	13·3790882	5·6357408	·005586592
180	32400	5832000	13·4164079	5·6462162	·005555556
181	32761	5929741	13·4536240	5·6566528	·005524862
182	33124	6028568	13·4907376	5·6670511	·005494505
183	33489	6128487	13·5277493	5·6774114	·005464481
184	33856	6229504	13·5646600	5·6877340	·005434783
185	34225	6331625	13·6014705	5·6980192	·005405405
186	34596	6434856	13·6381817	5·7082675	·005376344
187	34969	6539203	13·6747943	5·7184791	·005347594

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
188	35344	6644672	13·7113092	5·7286543	·005319149
189	35721	6751269	13·7477271	5·7387936	005291005
190	36100	6859000	13·7840488	5·7488971	·005263158
191	36481	6967871	13·8202750	5·7589652	·005235602
192	36864	7077888	13·8564065	5·7689982	·005208333
193	37249	7189057	13·8924400	5·7789966	·005181347
194	37636	7301384	13·9283883	5·7889604	·005154639
195	38025	7414875	13·9642400	5·7988900	·005128205
196	38416	7529536	14·0000000	5·8087857	·005102041
197	38809	7645373	14·0356688	5·8186479	·005076142
198	39204	7762392	14·0712473	5·8284867	·005050505
199	39601	7880599	14·1067360	5 8382725	·005025126
200	40000	8000000	14·1421356	5·8480355	·005000000
201	40401	8120601	14·1774469	5·8577660	·004975124
202	40804	8242408	14 2126704	5·8674673	·004950495
203	41209	8365427	14·2478068	5·8771307	·004926108
204	41616	8489664	14·2828569	5·8867653	·004901961
205	42025	8615125	14·3178211	5·8963685	·004878049
206	42436	8741816	14·3527001	5·9059406	·004854369
207	42849	8869743	14·3874946	5·9154817	·004830918
208	43264	8998912	14·4222051	5·9249921	·004807692
209	43681	9129329	14·4568323	5·9344721	·004784689
210	44100	9261000	14·4913767	5 9439220	·004761905
211	44521	9393931	14·5258390	5 9533418	·004739336
212	44944	9528128	14·5602198	5·9627320	·004716981
213	45369	9663597	14·5945195	5·9720926	·004694836
214	45796	9800344	14·6287388	5·9814240	·004672897
215	46225	9938375	14·6628783	5·9907264	·004651163
216	46656	10077696	14·6969385	6·0000000	·004629630
217	47089	10218313	14·7309199	6 0092450	·004608295
218	47524	10360232	14·7648231	6·0184617	·004587156
219	47961	10503459	14·7986486	6 0276502	·004566210
220	48400	10648000	14·8323970	6·0368107	·004545455
221	48841	10793861	14·8660687	6 0459435	·004524887
222	49284	10941048	14·8996644	6·0550489	·004504505
223	49729	11089567	14·9331845	6·0641270	·004484305
224	50176	11239424	14·9666295	6·0731779	·004464286
225	50625	11390625	15·0000000	6·0824020	·004444444
226	51076	11543176	15·0332964	6·0391994	·004424779
227	51529	11697083	15·0665192	6·1001702	·004405286
228	51984	11852352	15·0996689	6·1091147	·004385965
229	52441	12008989	15·1327460	6·1180332	·004366812
230	52900	12167000	15·1657509	6·1269257	·004347826
231	53361	12326391	15·1986842	6·1357924	·004329004
232	53824	12487168	15·2315462	6·1446337	·004310345
233	54289	12649337	15·2643375	6·1534495	·004291845
234	54756	12812904	15·2970585	6·1622401	·004273504
235	55225	12977875	15·3297097	6·1710058	·004255319
236	55696	13144256	15·3622915	6·1797466	·004237288
237	56169	13312053	15·3948043	6·1884628	·004219409
238	56644	13481272	15·4272486	6·1971544	·004201681
239	57121	13651919	15·4596248	6·2058218	·004184100
240	57600	13824000	15·4919334	6·2144650	·004166667
241	58081	13997521	15·5241747	6·2230843	·004149378
242	58564	14172488	15·5563492	6·2316797	·004132231
243	59049	14348907	15·5884573	6·2402515	·004115226
244	59536	14526784	15·6204994	6·2487998	·004098361
245	60025	14706125	15·6524758	6·2573248	·004081633
246	60516	14886936	15·6843871	6·2658266	·004065041
247	61009	15069223	15·7162336	6·2743054	·004048583
248	61504	15252992	15·7480157	6·2827613	·004032258
249	62001	15438249	14·7797338	6·2911946	·004016064
250	62500	15625000	15·8113883	6·2996053	·004000000
251	*63001*	15813251	15·8429795	6·3079935	·003984064

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals
252	63504	16003004	15·8745079	6·3163596	·003968254
253	64009	16194279	15·9059737	6·3247035	·003952569
254	64516	16387064	15·9373775	6·3330256	·003937008
255	65025	16581375	15·9687194	6·3413257	·003921569
256	65536	16777216	16·0000000	6·3496042	·003906250
257	66049	16974593	16·0312195	6·3578611	·003891051
258	66564	17173512	16·0623784	6·3660968	·003875969
259	67081	17373979	16·0934769	6·3743111	·003861004
260	67600	17576000	16·1245155	6·3825043	·003846154
261	68121	17779581	16·1554944	6·3906765	·003831418
262	68644	17984728	16·1864141	6·3988279	·003816794
263	69169	18191447	16·2172747	6·4069585	·003802281
264	69696	18399744	16·2480768	6·4150687	·003787879
265	70225	18609625	16·2788206	6·4231583	·003773585
266	70756	18821096	16·3095064	6·4312276	·003759398
267	71289	19034163	16·3401346	6·4392767	·003745318
268	71824	19248832	16·3707055	6·4473057	·003731343
269	72361	19465109	16·4012195	6·4553148	·003717472
270	72900	19683000	16·4316767	6·4633041	·003703704
271	73441	19902511	16·4620776	6·4712736	·003690037
272	73984	20123648	16·4924225	6·4792236	·003676471
273	74529	20346417	16·5227116	6·4871541	·003663004
274	75076	20570824	16·5529454	6·4950653	·003649635
275	75625	20796875	16·5831240	6·5029572	·003636364
276	76176	21024576	16·6132477	6·5108300	·003623188
277	76729	21253933	16·6433170	6·5186839	·003610108
278	77284	21484952	16·6783320	6·5265189	·003597122
279	77841	21717639	16·7032931	6·5343351	·003584229
280	78400	21952000	16·7332005	6·5421326	·003571429
281	78961	22188041	16·7630546	6·5499116	·003558719
282	79524	22425768	16·7928556	6·5576722	·003546099
283	80089	22665187	16·8226038	6·5654144	·003533569
284	80656	22906304	16·8522995	6·5731385	·003521127
285	81225	23149125	16·8819430	6·5808443	·003508772
286	81796	23393656	16·9115345	6·5885323	·003496503
287	82369	23639903	16·9410743	6·5962023	·003484321
288	82944	23887872	16·9705627	6·6038545	·003472222
289	83521	24137569	17·0000000	6·6114890	·003460208
290	84100	24389000	17·0293864	6·6191060	·003448276
291	84681	24642171	17·0587221	6·6267054	·003436426
292	85264	24897088	17·0880075	6·6342874	·003424658
293	85849	25153757	17·1172428	6·6418522	·003412969
294	86436	25412184	17·1464282	6·6493998	·003401361
295	87025	25672375	17·1755640	6·6569302	·003389831
296	87616	25934336	17·2046505	6·6644437	·003378378
297	88209	26198073	17·2336879	6·6719403	·003367003
298	88804	26463592	17·2626765	6·6794200	·003355705
299	89401	26730899	17·2916165	6·6868831	·003344482
300	90000	27000000	17·3205081	6·6943295	·003333333
301	90601	27270901	17·3493516	6·7017593	·003322259
302	91204	27543608	17·3781472	6·7091729	·003311258
303	91809	27818127	17·4068952	6·7165700	·003301330
304	92416	28094464	17·4355958	6·7239508	·003289474
305	93025	28372625	17·4642492	6·7313155	·003278689
306	93636	28652616	17·4928557	6·7386641	·003267974
307	94249	28934443	17·5214155	6·7459967	·003257329
308	94864	29218112	17·5499288	6·7533134	·003246753
309	95481	29503629	17·5783958	6·7606143	·003236246
310	96100	29791000	17·6068169	6·7678995	·003225806
311	96721	30080231	17·6351921	6·7751690	·003215434
312	97344	30371328	17·6635217	6·7824229	·003205128
313	97969	30664297	17·6918060	6·7896613	·003194888
314	98596	30959144	17·7200451	6·7968844	·003184713
315	99225	31255875	17·7482393	6·8040921	·003174603

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
316	99856	31554496	17·7763888	6·8112847	·003164557
317	100489	31855013	17·8044938	6·8184620	·003154574
318	101124	32157432	17·8325545	6·8256242	·003144654
319	101761	32461759	17·8605711	6·8327714	·003134796
320	102400	32768000	17·8885438	6·8399037	·003125000
321	103041	33076161	17·9164729	6·8470213	·003115265
322	103684	33386248	17·9443584	6·8541240	·003105590
323	104329	33698267	17·9722008	6·8612120	·003095975
324	104976	34012224	18·0000000	6·8682855	·003086420
325	105625	34328125	18·0277564	6·8753433	·003076923
326	106276	34645976	18·0554701	6·8823888	·003067485
327	106929	34965783	18 0831413	6·8894188	·003058104
328	107584	35287552	18·1107703	6·8964345	·003048780
329	108241	35611289	18·1383571	6·9034359	·003039514
330	108900	35937000	18·1659021	6·9104232	·003030303
331	109561	36264691	18·1934054	6·9173964	·003021148
332	110224	36594368	18·2208672	6·9243556	·003012048
333	110889	36926037	18·2482876	6·9313088	·003003003
334	111556	37259704	18 2756669	6·9382321	·002994012
335	112225	37595375	18·3030052	6·9451496	·002985075
336	112896	37933056	18·3303028	6·9520533	·002976190
337	113569	38272753	18·3575598	6·9589434	·002967359
338	114244	38614472	18·3847763	6·9658198	·002958580
339	114921	38958219	18·4119526	6·9726826	·002949853
340	115600	39304000	18·4390889	6·9795321	·002941176
341	116281	39651821	18·4661853	6·9863681	·002932551
342	116964	40001688	18·4932420	6·9931906	·002923977
343	117649	40353607	18·5202592	7·0000000	·002915452
344	118336	40707584	18·5472370	7·0067962	·002906977
345	119025	41063625	18·5741756	7·0135791	·002898551
346	119716	41421736	18·6010752	7·0203490	·002890173
347	120409	41781923	18·6279360	7·0271058	·002881844
348	121104	42144192	18·6547581	7·0338497	·002873563
349	121801	42508549	18·6815417	7·0405860	·002865330
350	122500	42875000	18·7082869	7·0472987	·002857143
351	123201	43243551	18·7349940	7·0540041	·002849003
352	123904	48614208	18·7616630	7·0606967	·002840909
353	124609	43986977	18·7882942	7·0673767	·002832861
354	125316	44361864	18·8148877	7·0740440	·002824859
355	126025	44738875	18·8414437	7·0806988	·002816901
356	126736	45118016	18·8679623	7·0873411	·002808989
357	127449	45499293	18·8944436	7·0939709	·002801120
358	128164	45882712	18·9208879	7·1005885	·002793296
359	128881	46268279	18·9472953	7·1071937	·002785515
360	129600	46656000	18·9736660	7·1137866	·002777778
361	130321	47045881	19·0000000	7·1203674	·002770083
362	131044	47437928	19·0262976	7·1269360	·002762431
363	131769	47832147	19·0525589	7·1334925	·002754821
364	132496	48228544	19·0787840	7·1400370	·002747253
365	133225	48627125	19·1049732	7·1465695	·002739726
366	133956	49027896	19·1311265	7·1530901	002732240
367	134689	49430863	19·1572441	7·1595988	·002724796
368	135424	49836032	19·1883261	7·1660957	·002717391
369	136161	50243409	19·2093727	7·1725809	·002710027
370	136900	50653000	19·2353841	7·1790544	·002702703
371	137641	51064811	19·2613603	7·1855162	·002695418
372	138384	51478848	19·2873015	7·1919663	·002688172
373	139129	51895117	19·3132079	7·1984050	·002680965
374	139876	52313624	19·3390796	7·2048322	·002673797
375	140625	52734375	19·3649167	7·2112479	·002666667
376	141376	53157376	19·3907194	7·2176522	·002659574
377	142129	53582633	19·4164878	7·2240450	·002652520
378	142884	54010152	19 4422221	7·2304268	·002645503
379	*143641*	54439939	19·4679223	7·2367972	·002638521

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
380	144400	54872000	19·4935887	7·2431565	·002631579
381	145161	55306341	19·5192218	7·2495045	·002624672
382	145924	55742968	19·5448203	7·2558415	·002617801
383	146689	56181887	19·5703858	7·2621675	·002610966
384	147456	56623104	19·5959179	7·2684824	·002604167
385	148225	57066625	19·6214169	7·2747864	·002597403
386	148996	57512456	19·6468827	7·2810794	·002590674
387	149769	57960603	19·6723156	7·2873617	·002583979
388	150544	58411072	19·6977156	7·2936330	·002577320
389	151321	58863869	19·7230829	7·2998936	·002570694
390	152100	59319000	19·7484177	7·3061436	·002564103
391	152881	59776471	19·7737199	7·3123828	·002557545
392	153664	60236288	19·7989899	7·3186114	·002551020
393	154449	60698457	19·8242276	7·3248295	·002544529
394	155236	61162984	19·8494332	7·3310369	·002538071
395	156025	61629875	19·8746069	7·3372339	·002531646
396	156816	62099136	19·8997487	7·3434205	·002525253
397	157609	62570773	19·9248588	7·3495966	·002518892
398	158404	63044792	19·9499373	7·3557624	·002512563
399	159201	63521199	19·9749844	7·3619178	·002506266
400	160000	64000000	20·0000000	7·3680630	·002500000
401	160801	64481201	20·0249844	7·3741979	·002493766
402	161604	64964808	20·0499377	7·3803227	·002487562
403	162409	65450827	20·0748599	7·3864373	·002481390
404	163216	65939264	20·0997512	7·3925418	·002475248
405	164025	66430125	20·1246118	7·3986363	·002469136
406	164836	66923416	20·1494417	7·4047206	·002463054
407	165649	67419143	20·1742410	7·4107950	·002457002
408	166464	67917312	20·1990099	7·4168595	·002450980
409	167281	68417929	20·2237484	7·4229142	·002444988
410	168100	68921000	20·2484567	7·4289589	·002439024
411	168921	69426531	20·2731349	7·4349938	·002433090
412	169744	69934528	20·2977831	7·4410189	·002427184
413	170569	70444997	20·3224014	7·4470342	·002421308
414	171396	70957944	20·3469899	7·4530399	·002415459
415	172225	71473375	20·3715488	7·4590359	·002409639
416	173056	71991296	20·3960781	7·4650223	·002403846
417	173889	72511713	20·4205779	7·4709991	·002398082
418	174724	73034632	20·4450483	7·4769664	·002392344
419	175561	73560059	20·4694895	7·4829242	·002386635
420	176400	74088000	20·4939015	7·4888724	·002380952
421	177241	74618461	20·5182845	7·4948113	·002375297
422	178084	75151448	20·5426386	7·5007406	·002369668
423	178929	75686967	20·5669638	7·5066607	·002364066
424	179776	76225024	20·5912603	7·5125715	·002358491
425	180625	76765625	20·6155281	7·5184730	·002352941
426	181476	77308776	20·6397674	7·5243652	·002347418
427	182329	77854483	20·6639783	7·5302482	·002341920
428	183184	78402752	20·6881609	7·5361221	·002336449
429	184041	78953589	20·7123152	7·5419867	·002331002
430	184900	79507000	20·7364414	7·5478423	·002325581
431	185761	80062991	20·7605395	7·5536888	·002320186
432	186624	80621568	20·7846097	7·5595263	·002314815
433	187489	81182737	20·8086520	7·5653548	·002309469
434	188356	81746504	20·8326667	7·5711743	·002304147
435	189225	82312875	20·8566536	7·5769849	·002298851
436	190096	82881856	20·8806130	7·5827865	·002293578
437	190969	83453453	20·9045450	7·5885793	·002288330
438	191844	84027672	20·9284495	7·5943633	·002283105
439	192721	84604519	20·9523268	7·6001385	·002277904
440	193600	85184000	20·9761770	7·6059049	·002272727
441	194481	85766121	21·0000000	7·6116626	·002267574
442	195364	86350888	21·0237960	7·6174116	·002262443
443	196249	86938307	21·0475652	7·6231519	·002257336

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals
444	197136	87528384	21·0713075	7·6288837	·002252252
445	198025	88121125	21·0950231	7·6346067	·002247191
446	198916	88716536	21·1187121	7·6403213	·002242152
447	199809	89314623	21·1423745	7·6460272	·002237136
448	200704	89915392	21·1660105	7·6517247	·002232143
449	201601	90518849	21·1896201	7·6574138	·002227171
450	202500	91125000	21·2132034	7·6630943	·002222222
451	203401	91733851	21·2367606	7·6687665	·002217295
452	204304	92345408	21·2602916	7·6744303	·002212389
453	205209	92959677	21·2837967	7·6800857	·002207506
454	206116	93576664	21·3072758	7·6857328	·002202643
455	207025	94196375	21·3307290	7·6913717	·002197802
456	207936	94818816	21·3541565	7·6970023	·002192982
457	208849	95443993	21·3775583	7·7026246	·002188184
458	209764	96071912	21·4009346	7·7082388	·002183406
459	210681	96702579	21·4242853	7·7138448	·002178649
460	211600	97336000	21·4476106	7·7194426	·002173913
461	212521	97972181	21·4709106	7·7250325	·002169197
462	213444	98611128	21·4941853	7·7306141	·002164502
463	214369	99252847	21·5174348	7·7361877	·002159827
464	215296	99897344	21·5406592	7·7417532	·002155172
465	216225	100544625	21·5638587	7·7473109	·002150538
466	217156	101194696	21·5870331	7·7528606	·002145923
467	218089	101847563	21·6101828	7·7584023	·002141328
468	219024	102503232	21·6333077	7·7639361	·002136752
469	219961	103161709	21·6564078	7·7694620	·002132196
470	220900	103823000	21·6794834	7·7749801	·002127660
471	221841	104487111	21·7025344	7·7804904	·002123142
472	222784	105154048	21·7255610	7·7859928	·002118644
473	223729	105823817	21·7485632	7·7914875	·002114165
474	224676	106496424	21·7715411	7·7969745	·002109705
475	225625	107171875	21·7944947	7·8024538	·002105263
476	226576	107850176	21·8174242	7·8079254	·002100840
477	227529	108531333	21·8403297	7·8133892	·002096436
478	228484	109215352	21·8632111	7·8188456	·002092050
479	229441	109902239	21·8860686	7·8242942	·002087683
480	230400	110592000	21·9089023	7·8297353	·002083333
481	231361	111284641	21·9317122	7·8351688	·002079002
482	232324	111980168	21·9544984	7·8405949	·002074689
483	233289	112678587	21·9772610	7·8460134	·002070393
484	234256	113379904	22·0000000	7·8514244	·002066116
485	235225	114084125	22·0227155	7·8568281	·002061856
486	236196	114791256	22·0454077	7·8622242	·002057613
487	237169	115501303	22·0680765	7·8676130	·002053388
488	238144	116214272	22·0907220	7·8729944	·002049180
489	239121	116930169	22·1133444	7·8783684	·002044990
490	240100	117649000	22·1359436	7·8837352	·002040816
491	241081	118370771	22·1585198	7·8890946	·002036660
492	242064	119095488	22·1810730	7·8944468	·002032520
493	243049	119823157	22·2036033	7·8997917	·002028398
494	244036	120553784	22·2261108	7·9051294	·002024291
495	245025	121287375	22·2485955	7·9104599	·002020202
496	246016	122023936	22·2710575	7·9157832	·002016129
497	247009	122763473	22·2934968	7·9210994	·002012072
498	248004	123505992	22·3159136	7·9264085	·002008032
499	249001	124251499	22·3383079	7·9317104	·002004008
500	250000	125000000	22·3606798	7·9370053	·002000000
501	251001	125751501	22·3830293	7·9422931	·001996008
502	252004	126506008	22·4053565	7·9475739	·001992032
503	253009	127263527	22·4276615	7·9528477	·001988072
504	254016	128024064	22·4499443	7·9581144	·001984127
505	255025	128787625	22·4722051	7·9633743	·001980198
506	256036	129554216	22·4944438	7·9686271	·001976285
507	257049	130323843	22·5166605	7·9738731	·001972387

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
508	258064	131096512	22·5388553	7·9791122	·001968504
509	259081	131872229	22·5610283	7·9843444	·001964637
510	260100	132651000	22·5831796	7·9895697	·001960784
511	261121	133432831	22·6053091	7·9947883	·001956947
512	262144	134217728	22·6274170	8·0000000	·001953125
513	263169	135005697	22·6495033	8·0052049	·001949318
514	264196	135796744	22·6715681	8·0104032	·001945525
515	265225	136590875	22·6936114	8·0155946	·001941748
516	266256	137388096	22·7156334	8·0207794	·001937984
517	267289	138188413	22·7376341	8·0259574	·001934236
518	268324	138991832	22·7596134	8·0311287	·001930502
519	269361	139798359	22·7815715	8·0362935	·001926782
520	270400	140608000	22·8035085	8·0414515	·001923077
521	271441	141420761	22·8254244	8·0466030	·001919386
522	272484	142236648	22·8473193	8·0517479	·001915709
523	273529	143055667	22·8691933	8·0568862	·001912046
524	274576	143877824	22·8910463	8·0620180	·001908397
525	275625	144703125	22·9128785	8·0671432	·001904762
526	276676	145531576	22·9346899	8·0722620	·001901141
527	277729	146363183	22·9564806	8·0773743	·001897533
528	278784	147197952	22·9782506	8·0824800	·001893939
529	279841	148035889	23·0000000	8·0875794	·001890359
530	280900	148877000	23·0217289	8·0926723	·001886792
531	281961	149721291	23·0434372	8 0977589	·001883239
532	283024	150568768	23·0651252	8·1028390	·001879699
533	284089	151419437	23·0867928	8·1079128	·001876173
534	285156	152273304	23·1084400	8·1129803	·001872659
535	286225	153130375	23·1300670	8·1180414	·001869159
536	287296	153990656	23·1516738	8·1230962	·001865672
537	288369	154854153	23·1732605	8·1281447	·001862197
538	289444	155720872	23·1948270	8·1331870	·001858736
539	290521	156590819	23·2163735	8·1382230	·001855288
540	291600	157464000	23·2379001	8·1432529	·001851852
541	292681	158340421	23·2594067	8·1482765	·001848429
542	293764	159220088	23·2808935	8·1532939	·001845018
543	294849	160103007	23·3023604	8·1583051	·001841621
544	295936	160989184	23·3238076	8·1633102	·001838235
545	297025	161878625	23·3452351	8·1683092	·001834862
546	298116	162771336	23·3666429	8·1733020	·001831502
547	299209	163667323	23·3880311	8·1782888	·001828154
548	300304	164566592	23·4093998	8·1832695	·001824818
549	301401	165469149	23·4307490	8·1882441	·001821494
550	302500	166375000	23·4520788	8·1932127	·001818182
551	303601	167284151	23·4733892	8·1981753	·001814882
552	304704	168196608	23·4946802	8·2031319	·001811594
553	305809	169112377	23·5159520	8·2080825	·001808318
554	306916	170031464	23·5372046	8·2130271	·001805054
555	308025	170953875	23·5584380	8·2179657	·001801802
556	309136	171879616	23·5796522	8·2228985	·001798561
557	310249	172808693	23·6008474	8·2278254	·001795332
558	311364	173741112	23·6220236	8·2327463	·001792115
559	312481	174676879	23·6431808	8·2376614	·001788909
560	313600	175616000	23·6643191	8·2425706	·001785714
561	314721	176558481	23·6854386	8·2474740	·001782531
562	315844	177504328	23·7065392	8·2523715	·001779356
563	316969	178453547	23·7276210	8·2572635	·001776190
564	318096	179406144	23·7486842	8·2621492	·001773052
565	319225	180362125	23·7697286	8·2670294	·001769918
566	320356	181321496	23·7907545	8·2719039	·001766784
567	321489	182284263	23·8117618	8·2767726	·001763669
568	322624	183250432	23·8327506	8·2816255	·001760563
569	323761	184220009	23·8537209	8·2864928	·001757469
570	324900	185193000	23·8746728	8·2913444	·001754386
571	326041	186169411	23·8956063	8·2961903	·001751313

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
572	327184	187149248	23·9165215	8·3010304	·001748252
573	328329	188132517	23·9374184	8·3058651	·001745201
574	329476	189119224	23·9582971	8·3106941	·001742160
575	330625	190109375	23·9791576	8·3155175	·001739130
576	331776	191102976	24·0000000	8·3203353	·001736111
577	332929	192100033	24·0208243	8·3251475	·001733102
578	334084	193100552	24·0416306	8·3299542	·001730104
579	335241	194104539	24·0624188	8·3347553	·001727116
580	336400	195112000	24·0831891	8·3395509	·001724138
581	337561	196122941	24·1039416	8·3443410	·001721170
582	338724	197137368	24·1246762	8·3491256	·001718213
583	339889	198155287	24·1453929	8·3539047	·001715266
584	341056	199176704	24·1660919	8·3586784	·001712329
585	342225	200201625	24·1867732	8·3634466	·001709402
586	343396	201230056	24·2074369	8·3682095	·001706485
587	344569	202262003	24·2280829	8·3729668	·001703578
588	345744	203297472	24·2487113	8·3777188	·001700680
589	346921	204336469	24·2693222	8·3824653	·001697793
590	348100	205379000	24·2899156	8·3872065	·001694915
591	349281	206425071	24·3104996	8·3919423	·001692047
592	350464	207474688	24·3310501	8·3966729	·001689189
593	351649	208527857	24·3515913	8·4013981	·001686341
594	352836	209584584	24·3721152	8·4061180	·001683502
595	354025	210644875	24·3926218	8·4108326	·001680672
596	355216	211708736	24·4131112	8·4155419	·001677852
597	356409	212776173	24·4335834	8·4202460	·001675042
598	357604	213847192	24·4540385	8·4249448	·001672241
599	358801	214921799	24·4744765	8·4296383	·001669449
600	360000	216000000	24·4948974	8·4343267	·001666667
601	361201	217081801	24·5153013	8·4390098	·001663894
602	362404	218167208	24·5356883	8·4436877	·001661130
603	363609	219256227	24·5560583	8·4483605	·001658375
604	364816	220348864	24·5764115	8·4530281	·001655629
605	366025	221445125	24·5967478	8·4576906	·001652893
606	367236	222545016	24·6170673	8·4623479	·001650165
607	368449	223648543	24·6373700	8·4670001	·001647446
608	369664	224755712	24·6576560	8·4716471	·001644737
609	370881	225866529	24·6779254	8·4762892	·001642036
610	372100	226981000	24·6981781	8·4809261	·001639344
611	373321	228099131	24·7184142	8·4855579	·001636661
612	374544	229220928	24·7386338	8·4901848	·001633987
613	375769	230346397	24·7588368	8·4948065	·001631321
614	376996	231475544	24·7790234	8·4994233	·001628664
615	378225	232608375	24·7991935	8·5040350	·001626016
616	379456	233744896	24·8193473	8·5086417	·001623377
617	380689	234885113	24·8394847	8·5132435	·001620746
618	381924	236029032	24·8596058	8·5178403	·001618123
619	383161	237176659	24·8797106	8·5224331	·001615509
620	384400	238328000	24·8997992	8·5270189	·001612903
621	385641	239483061	24·9198716	8·5316009	·001610306
622	386884	240641848	24·9399278	8·5361780	·001607717
623	388129	241804367	24·9599679	8·5407501	·001605136
624	389376	242970624	24·9799920	8·5453173	·001602564
625	390625	244140625	25·0000000	8·5498797	·001600000
626	391876	245134376	25·0199920	8·5544372	·001597444
627	393129	246491883	25·0399681	8·5589899	·001594896
628	394384	247673152	25·0599282	8·5635377	·001592357
629	395641	248858189	25·0798724	8·5680807	·001589825
630	396900	250047000	25·0998008	8·5726189	·001587302
631	398161	251239591	25·1197134	8·5771523	·001584786
632	399424	252435968	25·1396102	8·5816809	·001582278
633	400689	253636137	25·1594913	8·5862247	·001579779
634	401956	254840104	25·1793566	8·5907238	·001577287
635	403225	256047875	25·1992063	8·5952380	·001574803

ers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
	404496	257259456	25·2190404	8·5997476	·001572327
	405769	258474853	25·2388589	8·6042525	·001569859
	407044	259694072	25·2586619	8·6087526	·001567398
	408321	260917119	25·2784493	8·6132480	·001564945
	409600	262144000	25·2982213	8·6177388	·001562500
	410881	263374721	25·3179778	8·6222248	·001560062
	412164	264609288	25·3377189	8·6267063	·001557632
	413449	265847707	25·3574447	8·6311830	·001555210
	414736	267089984	25·3771551	8·6356551	·001552795
	416025	268336125	25·3968502	8·6401226	·001550388
	417316	269586136	25·4165302	8·6445855	·001547988
	418609	270840023	25·4361947	8·6490437	·001545595
	419904	272097792	25·4558441	8·6534974	·001543210
	421201	273359449	25·4754784	8·6579465	·001540832
	422500	274625000	25·4950976	8·6623911	·001538462
	423801	275894451	25·5147013	8·6668310	·001536098
	425104	277167808	25·5342907	8·6712665	·001533742
	426409	278445077	25·5538647	8·6756974	·001531394
	427716	279726264	25·5734237	8·6801237	·001529052
	429025	281011375	25·5929678	8·6845456	·001526718
	430336	282300416	25·6124969	8·6889630	·001524390
	431649	283593393	25·6320112	8·6933759	·001522070
	432964	284890312	25·6515107	8·6977843	·001519751
	434281	286191179	25·6709953	8·7021882	·001517451
	435600	287496000	25·6904652	8·7065887	·001515152
	436921	288804781	25·7099203	8·7109827	·001512859
	438244	290117528	25·7293607	8·7153734	·001510574
	439569	291434247	25·7487864	8·7197596	·001508296
	440896	292754944	25·7681975	8·7241414	·001506024
	442235	294079625	25·7875939	8·7285187	·001503759
	443556	295408296	25·8069758	8·7328918	·001501502
	444899	296740963	25·8263431	8·7372604	·001499250
	446224	298077632	25·8456960	8·7416246	·001497006
	447561	299418309	25·8650343	8·7459846	·001494768
	448900	300763000	25·8843582	8·7503401	·001492537
	450241	302111711	25·9036677	8·7546913	·001490313
	451584	303464448	25·9229628	8·7590383	·001488095
	452929	304821217	25·9422435	8·7633809	·001485884
	454276	306182024	25·9615100	8·7677192	·001483680
	455625	307546875	25·9807621	8·7720532	·001481481
	456976	308915776	26·0000000	8·7763830	·001479290
	458329	310288733	26·0192237	8·7807084	·001477105
	459684	311665752	26·0384331	8·7850296	·001474926
	461041	313046839	26·0576284	8·7893466	·001472754
	462400	314432000	26·0768096	8·7936593	·001470588
	463761	315821241	26·0959767	8·7979679	·001468429
	465124	317214568	26·1151297	8·8022721	·001466276
	466489	318611987	26·1342687	8·8065722	·001464129
	467856	320013504	26·1533937	8·8108681	·001461988
	469225	321419125	26·1725047	8·8151598	·001459854
	470596	322828856	26·1916017	8·8194474	·001457726
	471969	324242703	26·2106848	8·8237307	·001455604
	473344	325660672	26·2297641	8·8280099	·001453488
	474721	327082769	26·2488095	8·8322850	·001451379
	476100	328509000	26·2678511	8·8365559	·001449275
	477481	329939371	26·2868789	8·8408227	·001447178
	478864	331373888	26·3058929	8·8450854	·001445087
	480249	332812557	26·3248932	8·8493440	·001443001
	481636	334255384	26·3438797	8·8535985	·001440922
	483025	335702375	26·3628527	8·8578489	·001438849
	484416	337153536	26·3818119	8·8620952	·001436782
	485809	338608873	26·4007576	8·8663375	·001434720
	487204	340068392	26·4196896	8·8705757	·001432665
	488601	341532099	26·4386081	8·8748099	·001430615

Numbers.	Squares.	Cubes	Square Roots.	Cube Roots.	Reciprocals
700	490000	343000000	26·4575131	8·8790400	·001428571
701	491401	344472101	26·4764046	8·8832661	·001426534
702	492804	345948408	26·4952826	8·8874882	·001424501
703	494209	347428927	26·5141472	8·8917063	·001422475
704	495616	348913664	26·5329983	8·8959204	·001420455
705	497025	350402625	26·5518361	8·9001304	·001418440
706	498436	351895816	26·5706605	8·9043366	·001416431
707	499849	353393243	26·5894716	8·9085387	·001414427
708	501264	354894912	26·6082694	8·9127369	·001412429
709	502681	356400829	26·6270539	8·9169311	·001410437
710	504100	357911000	26·6458252	8·9211214	·001408451
711	505521	359425431	26·6645833	8 9253078	·001406470
712	506944	360944128	26·6833281	8·9294092	·001404494
713	508369	362467097	26·7020598	8·9336687	·001402525
714	509796	363994344	26·7207784	8·9378433	·001400560
715	511225	365525875	26·7394839	8·9420140	·001398601
716	512656	367061696	26·7581763	8·9461809	·001396648
717	514089	368601813	26·7768557	8 9503438	·001394700
718	515524	370146232	26·7955220	8·9545029	·001392758
719	516961	371694959	26·8141754	8·9586581	·001390821
720	518400	373248000	26·8328157	8·9628095	·001388889
721	519841	374805361	26·8514432	8·9669570	·001386963
722	521284	376367048	26·8700577	8·9711007	·001385042
723	522729	377933067	26·8886593	8·9752406	·001383126
724	524176	379503424	26·9072481	8·9793766	·001381215
725	525625	381078125	26·9258240	8·9835089	·001379310
726	527076	382657176	26·9443872	8·9876373	·001377410
727	528529	384240583	26·9629375	8·9917620	·001375516
728	529984	385828352	26·9814751	8·9958899	001373626
729	531441	387420489	27·0000000	9·0000000	001371742
730	532900	389017000	27·0185122	9·0041134	·001369863
731	534361	390617891	27·0370117	9·0082229	·001367989
732	535824	392223168	27·0554985	9·0123288	·001366120
733	537289	393832837	27·0739727	9·0164309	·001364256
734	538756	395446904	27·0924344	9·0205293	·001362398
735	540225	397065375	27·1108834	9·0246239	·001360544
736	541696	398688256	27·1293199	9·0287149	·001358696
737	543169	400315553	27·1477149	9 0328021	·001356852
738	544644	401947272	27·1661554	9·0368857	·001355014
739	546121	403583419	27·1845544	9·0409655	·001353180
740	547600	405224000	27·2029140	9·0450419	·001351351
741	549081	406869021	27·2213152	9·0491142	·001349528
742	550564	408518488	27·2396769	9·0531831	·001347709
743	552049	410172407	27·2580263	9·0572482	·001345895
744	553536	411830784	27·2763634	9·0613098	·001344086
745	555025	413493625	27·2946881	9·0653677	·001342282
746	556516	415160936	27·3130006	9·0694220	·001340483
747	558009	416832723	27·3313007	9 0734726	·001338688
748	559504	418508992	27·3495887	9·0775197	·001336898
749	561001	420189749	27·3678644	9·0815631	·001335113
750	562500	421875000	27·3861279	9·0856030	·001333333
751	564001	423564751	27·4043792	9·0896352	·001331558
752	565504	425259008	27·4226184	9·0936719	·001329787
753	567009	426957777	27·4408455	9·0977010	·001328021
754	568516	428661064	27·4590604	9·1017265	·001326260
755	570025	430368875	27·4772633	9·1057485	·001324503
756	571536	432081216	27·4954542	9·1097669	·001322751
757	573049	433798093	27·5136330	9·1137818	·001321004
758	574564	435519512	27·5317998	9·1177931	·001319261
759	576081	437245479	27·5499546	9·1218010	·001317523
.60	577600	438976000	27·5680975	9·1258053	·001315789
761	579121	440711081	27·5862284	9·1298061	·001314060
762	580644	442450728	27·6043475	9·1338034	·001312336
763	582169	444194947	27·6224546	9·1377971	·001310616

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
764	583696	445943744	27·6405499	9·1417874	·001308901
765	585225	447697125	27·6586334	9·1457742	·001307190
766	586756	449455096	27·6767050	9·1497576	·001305483
767	588289	451217663	27·6947648	9·1537375	·001303781
768	589824	452984832	27·71_8129	9·1577139	·001302083
769	591361	454756609	27·7308492	9·1616869	·001300390
770	592900	456533000	27·7488739	9·1656565	·001298701
771	594441	458314011	27·7668868	9·1696225	·001297017
772	595984	460099648	27·7848880	9·1735852	·001295337
773	597529	461889917	27·8028775	9·1775445	·001293661
774	599076	463684824	27·8208555	9·1815003	·001291990
775	600625	465484375	27·8388218	9·1854527	·001290323
776	602176	467288576	27·8567766	9·1894018	·001288660
777	603729	469097433	27·8747197	9·1933474	·001287001
778	605284	470910952	27·8926514	9·1972897	·001285347
779	606841	472729139	27·9105715	9·2012286	·001283697
780	608400	474552000	27·9284801	9·2051641	·001282051
781	609961	476379541	27·9463772	9·2090962	·001280410
782	611524	478211768	27·9642629	9·2130250	·001278772
783	613089	480048687	27·9821372	9·2169505	·001277139
784	614656	481890304	28·0000000	9·2208726	·001275510
785	616225	483736625	28·0178515	9·2247914	·001273885
786	617796	485587656	28·0356915	9·2287068	·001272265
787	619369	487443403	28·0535203	9·2326189	·001270648
788	620944	489303872	28·0713377	9·2365277	·001269036
789	622521	491169069	28·0891438	9·2404333	·001267427
790	624100	493039000	28·1069386	9·2443355	·001265823
791	625681	494913671	28·1247222	9·2482344	·001264223
792	627264	496793088	28·1424946	9·2521300	·001262626
793	628849	498677257	28·1602557	9·2560224	·001261034
794	630436	500566184	28 1780056	9·2599114	·001259446
795	632025	502459875	28·1957444	9 2637973	·001257862
796	633616	504358336	28·2134720	9·2676798	·001256281
797	635209	506261573	28·2311884	9·2715592	·001254705
798	636804	508169592	28·2488938	9·2754352	·001253133
799	638401	510082399	28·2665881	9·2793081	·001251564
800	640000	512000000	28·2842712	9·2831777	·001250000
801	641601	513922401	28·3019434	9·2870444	·001248439
802	643204	515849608	28·3196045	9·2909072	·001246883
803	944809	517781627	28·3372546	9·2947671	·001245330
804	646416	519718464	28·3548938	9 2986239	·001243781
805	648025	521660125	28·3725219	9·3024775	·001242236
806	649636	523606616	28·3901391	9·3063278	·001240695
807	651249	525557943	28·4077454	9·3101750	·001239157
808	652864	527514112	28·4253408	9·3140190	·001237624
809	654481	529475129	28·4429253	9·3178599	·001236094
810	656100	531441000	28·4604989	9·3216975	·001234568
811	657721	533411731	28·4780617	9·3255320	·001233046
812	659344	535387328	28·4956137	9·3293634	·001231527
813	660969	537367797	28·5131549	9·3331916	·001230012
814	662596	539353144	28·5306852	9·3370167	·001228501
815	664225	541343375	28·5482048	9·3408386	·001226994
816	665856	543338496	28·5657137	9·3446575	·001225499
817	667489	545338513	28·5832119	9·3484731	·001223990
818	669124	547343432	28·6006993	9·3522857	·001222494
819	670761	549353259	28·6181760	9·3560952	·001221001
820	672400	551368000	28·6356421	9·3599016	·001219512
821	674041	553387661	28·6530976	9·3637049	·001218027
822	675684	555412248	28·6705424	9·3675051	·001216545
823	677329	557441767	28·6879716	9·3713022	·001215067
824	678976	559476224	28·7054002	9·3750963	·001213592
825	680625	561515625	28·7228132	9·3788873	·001212121
826	682276	563559976	28·7402157	9·3826752	·001210654
827	683929	565609283	28·7576077	9·3864600	·001209190

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals
828	685584	567663552	28·7749891	9·3902419	·001207729
829	687241	569722789	28·7923601	9·3940206	·001206273
830	688900	571787000	28·8097206	9·3977964	·001204819
831	690561	573856191	28·8270706	9·4015691	·001203369
832	692224	575930368	28·8444102	9·4053387	·001201923
833	693889	578009537	28·8617394	9·4091054	·001200480
834	695556	580093704	28·8790582	9·4128690	·001199041
835	697225	582182875	28·8963666	9·4166297	·001197605
836	698896	584277056	28·9136646	9·4203873	·001196172
837	700569	586376253	28·9309523	9·4241420	·001194743
838	702244	588480472	28·9482297	9·4278936	·001193317
839	703921	590589719	28·9654967	9·4316423	·001191895
840	705600	592704000	28·9827535	9·4353800	·001190476
841	707281	594823321	29·0000000	9·4391307	·001189061
842	708964	596947688	29·0172363	9·4428704	·001187648
843	710649	599077107	29·0344623	9·4466072	·001186240
844	712336	601211584	29·0516781	9·4503410	·001184834
845	714025	603351125	29·0688837	9·4540719	·001183432
846	715716	605495736	29·0860791	9·4577999	·001182033
847	717409	607645423	29·1032644	9·4615249	·001180638
848	719104	609800192	29·1204396	9·4652470	·001179245
849	720801	611960046	29·1376046	9·4689661	·001177856
850	722500	614125000	29·1547595	9·4726824	·001176471
851	724201	616295051	29·1719043	9·4763957	·001175088
852	725904	618470208	29·1890390	9·4801061	·001173709
853	727609	620650477	29·2061637	9·4838136	·001172333
854	729316	622835864	29·2232784	9·4875128	·001170960
855	731025	625026375	29·2403830	9·4912200	·001169591
856	732736	627222016	29·2574777	9·4949188	·001168224
857	734449	629422793	29·2745623	9·4986147	·001166861
858	736164	631628712	29·2916370	9·5023078	·001165501
859	737881	633839779	29·3087018	9·5059980	·001164144
860	739600	636056000	29·3257566	9·5096854	·001162791
861	741321	638277381	29·3428015	9·5133699	·001161440
862	743044	640503928	29·3598365	9·5170515	·001160093
863	744769	642735647	29·3768616	9·5207303	·001158749
864	746496	644972544	29·3938769	9·5244063	·001157407
865	748225	647214625	29·4108823	9·5280794	·001156069
866	749956	649461896	29·4278779	9·5317497	·001154734
867	751689	651714363	29·4448637	9·5354172	·001153403
868	753424	653972032	29·4618397	9·5390818	·001152074
869	755161	656234909	29·4788059	9·5427437	·001150748
870	756900	658503000	29·4957624	9·5464027	·001149425
871	758641	660776311	29·5127091	9·5500589	·001148106
872	760384	663054848	29·5296461	9·5537123	·001146789
873	762129	665338617	29·5465734	9·5573630	·001145475
874	763876	667627624	29·5634910	9·5610108	·001144165
875	765625	669921875	29·5803989	9·5646559	·001142857
876	767376	672221376	29·5972972	9·5682782	·001141553
877	769129	674526133	29·6141858	9·5719377	·001140251
878	770884	676836152	29·6310648	9·5755745	·001138952
879	772641	679151439	29·6479342	9·5792085	·001137656
880	774400	681472000	29·6647939	9·5828397	·001136364
881	776161	683797841	29·6816442	9·5864682	·001135074
882	777924	686128968	29·6984848	9·5900937	·001133787
883	779689	688465387	29·7153159	9·5937169	·001132503
884	781456	690807104	29·7321375	9·5973373	·001131222
885	783225	693154125	29·7489496	9·6009548	·001129944
886	784996	695506456	29·7657521	9·6045696	·001128668
887	786769	697864103	29·7825452	9·6081817	·001127396
888	788544	700227072	29·7993289	9·6117911	·001126126
889	790321	702595369	29·8161030	9·6153977	·001124859
890	*792100*	704969000	29·8328678	9·6190017	·001123596
891	*793881*	707347971	29·8496231	9·6226030	·001122334

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
892	795664	707932288	29·8663690	9·6262016	·001121076
893	797449	712121957	29·8831056	9·6297975	·001119821
894	799236	714516984	29·8998328	9·6333907	·001118568
895	801025	716917375	29·9165506	9·6369812	·001117818
896	802816	719323136	29·9332591	9·6405690	·001116071
897	804609	721734273	29·9499583	9·6441542	·001114827
898	806404	724150792	29·9666481	9·6477367	·001113586
899	808201	726572699	29·9833287	9·6513166	·001112347
900	810000	729000000	30·0000000	9·6548938	·001111111
901	811801	731432701	30·0166621	9·6584684	·001109878
902	813604	733870808	30·0333148	9·6620403	·001108647
903	815409	736314327	30·0499584	9·6656096	·001107420
904	817216	738763264	30·0665928	9·6691762	·001106195
905	819025	741217625	30·0832179	9·6727403	·001104972
906	820836	743677416	30·0998339	9·6763017	·001103753
907	822649	746142643	30·1164407	9·6798604	·001102536
908	824464	748613312	30·1330383	9·6834166	·001101322
909	826281	751089429	30·1496269	9·6869701	·001100110
910	828100	753571000	30·1662063	9·6905211	·001098901
911	829921	756058031	30·1827765	9·6940694	·001097695
912	831744	758550528	30·1993377	9·6976151	·001096491
913	833569	761048497	30·2158899	9·7011583	·001095290
914	835396	763551944	30·2324329	9·7046989	·001094092
915	837225	766060875	30·2489669	9·7082369	·001092896
916	839056	768575296	30·2654919	9·7117723	·001091703
917	840889	771095213	30·2820079	9·7153051	·001090513
918	842724	773620632	30·2985148	9 7188354	·001089325
919	844561	776151559	30·3150128	9·7223631	·001088139
920	846400	778688000	30·3315018	9·7258883	·001086957
921	848241	781229961	30·3479818	9·7294109	·001085776
922	850084	783777448	30·3644529	9·7329309	·001084599
923	851929	786330467	30·3809151	9·7364484	·001083423
924	853776	788889024	30·3973683	9·7399634	·001082251
925	855625	791453125	30·4138127	9·7434758	·001081081
926	857476	794022776	30·4302481	9·7469857	·001079914
927	859329	796597983	30·4466747	9·7504930	·001078749
928	861184	799178752	30·4630924	9·7539979	·001077586
929	863041	801765089	30·4795013	9·7575002	·001076426
930	864900	804357000	30·4959014	9·7610001	·001075269
931	866761	806954491	30·5122926	9·7644974	·001074114
932	868624	809557568	30·5286750	9·7679922	·001072961
933	870489	812166237	30·5450487	9·7714845	·001071811
934	872356	814780504	30 5614136	9·7749743	·001070664
935	874225	817400375	30·5777697	9·7784616	·001069519
936	876096	820025856	30·5941171	9·7829466	·001068376
937	877969	822656953	30·6104557	9·7854288	·001067236
938	879844	825293672	30·6267857	9·7889087	·001066098
939	881721	827936019	30·6431069	9·7923861	·001064963
940	883600	830584000	30·6594194	9·7958611	·001063830
941	885481	833237621	30.6757233	0·7993336	·001062699
942	887364	835896888	30·6920185	9·8028036	·001061571
943	889249	838561807	30·7083051	9·8062711	·001060445
944	891136	841232384	30·7245830	9·8097362	·001059322
945	893025	843908625	30·7408523	9·8131989	·001058201
946	894916	846590536	30·7571130	9·8166591	·001057082
947	896808	849278123	30·7733651	9·8201169	·001055966
948	898704	851971392	30·7896086	9·8235723	·001054852
949	900601	854670349	30·8058436	9·8270252	·001053741
950	902500	857375000	30·8220700	9·8304757	·001052632
951	904401	860085351	30·8382879	9·8339288	·001051525
952	906304	862801408	30·8544972	9·8373695	·001050420
953	908209	865523177	30·8706981	9·8408127	·001049318
954	910116	868250664	30·8868904	9·8442536	·001048218
955	912025	870983875	30·9030743	9·8476920	·001047120

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Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
956	913936	873722816	30·9192477	9·8511280	·001046025
957	915849	876467493	30·9354166	9·8545617	·001044932
958	917764	879217912	30·9515751	9·8579929	·001043841
959	919681	881974079	30·9677251	9·8614218	·001042753
960	921600	884736000	30·9838668	9·8648483	·001041667
961	923521	887503681	31·0000000	9·8682724	·001040583
962	925444	890277128	31·0161248	9·8716941	·001039501
963	927369	893056347	31·0322413	9·8751135	·001038422
964	929296	895841344	31·0483494	9·8785305	·001037344
965	931225	898632125	31·0644491	9·8819451	·001036269
966	933156	901428696	31·0805405	9·8853574	·001035197
967	935089	904231063	31·0966236	9·8887673	·001034126
968	937024	907039232	31·1126984	9·8921749	·001033058
969	938961	909853209	31·1287648	9·8955801	·001031992
970	940900	912673000	31·1448230	9·8989830	·001030928
971	942841	915498611	31·1608729	9·9023835	·001029866
972	944784	918330048	31·1769145	9·9057817	·001028807
973	946729	921167317	31·1929479	9·9091776	·001027749
974	948676	924010424	31·2089731	9·9125712	·001026694
975	950625	926859375	31·2249900	9·9159624	·001025641
976	952576	929714176	31·2409987	9·9193518	·001024590
977	954529	932574833	31·2569992	9·9227379	·001023541
978	956484	935441352	31·2729915	9·9261222	·001022495
979	958441	938313739	31·2889757	9·9295042	·001021450
980	960400	941192000	31·3049517	9·9328839	·001020408
981	962361	944076141	31·3209195	9·9362613	·001019168
982	964324	946966168	31·3368792	9·9396363	·001018330
983	966289	949862087	31·3528308	9·9430092	·001017294
984	968256	952763904	31·3687743	9·9463797	·001016260
985	970225	955671625	31·3847097	9·9497479	·001015228
986	972196	958585256	31·4006369	9·9531138	·001014199
987	974169	961504803	31·4165561	9·9564775	·001013171
988	976144	964430272	31·4324673	9·9598389	·001012146
989	978121	967361669	31·4483704	9·9631981	·001011122
990	980100	970299000	31·4642654	9·9665549	·001010101
991	982081	973242271	31·4801525	9·9699055	·001009082
992	984064	976191488	31·4960315	9·9732619	·001008065
993	986049	979146657	31·5119025	9·9766120	·001007049
994	988036	982107784	31·5277655	9·9799599	·001006036
995	990025	985074875	31·5436206	9·9833055	·001005025
996	992016	988047936	31·5594677	9·9866488	·001004016
997	994009	991026973	31·5753068	9·9899900	·001003009
998	996004	994011992	31·5911380	9·9933289	·001002004
999	998001	997002999	31·6069613	9·9966656	·001001001
1000	1000000	1000000000	31·6227766	10·0000000	·001000000
1001	1002001	1003003001	31·6385840	10·0033222	·0009990010
1002	1004004	1006012008	31·6543866	10·0066622	·0009980040
1003	1006009	1009027027	31·6701752	10·0099899	·0009970090
1004	1008016	1012048064	31·6859590	10·0133155	·0009960159
1005	1010025	1015075125	31·7017349	10·0166389	·0009950249
1006	1012036	1018108216	31·7175030	10·0199601	·0009940358
1007	1014049	1021147343	31·7332633	10·0232791	·0009930487
1008	1016064	1024192512	31·7490157	10·0265958	·0009920635
1009	1018081	1027243729	31·7647603	10·0299104	·0009910803
1010	1020100	1030301000	31·7804972	10·0332228	·0009900990
1011	1022121	1033364331	31·7962262	10·0365330	·0009891197
1012	1024144	1036433728	31·8119474	10·0398410	·0009881423
1013	1026169	1039509197	31·8276609	10·0431469	·0009871668
1014	1028196	1042590744	31·8433666	10·0464506	·0009861933
1015	1030225	1045678375	31·8590646	10·0497521	·0009852217
1016	1032256	1048772096	31·8747549	10·0530514	·0009842520
1017	1034289	1051871913	31·8904374	10·0563485	·0009832842
1018	1036324	1054977832	31·9061123	10·0596435	·0009823183
1019	*1038361*	1058089859	31·9217794	10·0629364	·0009813543

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
1020	1040400	1061208000	31·9374388	10·0662271	·0009803922
1021	1042441	1064332261	31·9530906	10·0695156	·0009794319
1022	1044484	1067462648	31·9687347	10·0728020	·0009784736
1023	1046529	1070599167	31·9843712	10·0760868	·0009775171
1024	1048576	1073741824	32·0000000	10·0793684	·0009765625
1025	1050625	1076890625	32·0156212	10·0826484	·0009756098
1026	1052676	1080045576	32·0312348	10·0859262	·0009746589
1027	1054729	1083206683	32·0468407	10·0892019	·0009737098
1028	1056784	1086373952	32·0624391	10·0924755	·0009727626
1029	1058841	1089547389	32·0780298	10·0957469	·0009718173
1030	1060900	1092727000	32·0936131	10·0990163	·0009708738
1031	1062961	1095912791	32·1091887	10·1022835	·0009699321
1032	1065024	1099104768	32·1247568	10·1055487	·0009689922
1033	1067089	1102302937	32·1403173	10·1088117	·0009680542
1034	1069156	1105507304	32·1558704	10·1120726	·0009671180
1035	1071225	1108717875	32·1714159	10·1153314	·0009661836
1036	1073296	1111934656	32·1869539	10·1185882	·0009652510
1037	1075369	1115157653	32·2024844	10·1218428	·0009643202
1038	1077444	1118386872	32·2180074	10·1250953	·0009633911
1039	1079521	1121622319	32·2335229	10·1283457	·0009624639
1040	1081600	1124864000	32·2490310	10·1315941	·0009615385
1041	1083681	1128111921	32·2645316	10·1348403	·0009606148
1042	1085764	1131366088	32·2800248	10·1380845	·0009596929
1043	1087849	1134626507	32·2955105	10·1413266	·0009587738
1044	1089936	1137893184	32·3109888	10·1445667	·0009578544
1045	1092025	1141166125	32·3264598	10·1478047	·0009569378
1046	1094116	1144445336	32·3419233	10·1510406	·0009560229
1047	1096209	1147730823	32·3573794	10·1542744	·0009551098
1048	1098304	1151022592	32·3728281	10·1575062	·0009541985
1049	1100401	1154320649	32·3882695	10·1607359	·0009532888
1050	1102500	1157625000	32·4037035	10·1639636	·0009523810
1051	1104601	1160935651	32·4191301	10·1671893	·0009514748
1052	1106704	1164252608	32·4345495	10·1704129	·0009505703
1053	1108809	1167575877	32·4499615	10·1736344	·0009496676
1054	1110916	1170905464	32·4653662	10·1768539	·0009487666
1055	1113125	1174241375	32·4807635	10·1800714	·0009478673
1056	1115136	1177583616	32·4961536	10·1832868	·0009469697
1057	1117249	1180932193	32·5115364	10·1865002	·0009460738
1058	1119364	1184287112	32·5269119	10·1897116	·0009451796
1059	1121481	1187648379	32·5422802	10·1929209	·0009442871
1060	1123600	1191016000	32·5576412	10·1961283	·0009433962
1061	1125721	1194389981	32·5729949	10·1993336	·0009425071
1062	1127844	1197770328	32·5883415	10·2025369	·0009416196
1063	1129969	1201157047	32·6035807	10·2057382	·0009407338
1064	1132096	1204550144	32·6190129	10·2089375	·0009398496
1065	1134225	1207949625	32·6343377	10·2121347	·0009389671
1066	1136356	1211355496	32·6496554	10·2153300	·0009380863
1067	1138489	1214767763	32·6649659	10·2185233	·0009372071
1068	1140624	1218186432	32·6802693	10·2217146	·0009363296
1069	1142761	1221611509	32·6955654	10·2249039	·0009354537
1070	1144900	1225043000	32·7108544	10·2280912	·0009345794
1071	1147041	1228480911	32·7261363	10·2312766	·0009337068
1072	1149184	1231925248	32·7414111	10·2344599	·0009328358
1073	1151329	1235376017	32·7566787	10·2376413	·0009319664
1074	1153476	1238833224	32·7719392	10·2408207	·0009310987
1075	1155625	1242296875	32·7871926	10·2439981	·0009302326
1076	1157776	1245766976	32·8024398	10·2471735	·0009293680
1077	1159929	1249243533	32·8176782	10·2503470	·0009285051
1078	1162084	1252726552	32·8329103	10·2535186	·0009276438
1079	1164241	1256216039	32·8481354	10·2566881	·0009267841
1080	1166400	1259712000	32·8633535	10·2598557	·0009259259
1081	1168561	1263214441	32·8785644	10·2630213	·0009250694
1082	1170724	1266723368	32·8937684	10·2661850	·0009242144
1083	1172889	1270238787	32·9089653	10·2693467	·0009233610

Numbers	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
1084	1175056	1273760704	32·9241553	10·2725065	·0009225092
1085	1177225	1277289125	32·9393382	10·2756644	·0009216590
1086	1179396	1280824056	32·9545141	10·2788203	·0009208103
1087	1181569	1284365503	32·9696830	10·2819743	·0009199632
1088	1183744	1287913472	32·9848450	10·2851264	·0009191176
1089	1185921	1291467969	33·0000000	10·2882765	·0009182736
1090	1188100	1295029000	33·0151480	10·2914247	·0009174312
1091	1190281	1298596571	33·0302891	10·2945709	·0009165903
1092	1192464	1302170688	33·0454233	10·2977153	·0009157509
1093	1194649	1305751357	33·0605505	10·3008577	·0009149131
1094	1196836	1309338584	33·0756708	10·3039982	·0009140768
1095	1199025	1312932375	33·0907842	10·3071368	·0009132420
1096	1201216	1316532736	33·1058907	10·3102735	·0009124088
1097	1203409	1320139673	33·1209903	10·3134083	·0009115770
1098	1205604	1323753192	33·1360830	10·3165411	·0009107468
1099	1207801	1327373299	33·1511689	10·3196721	·0009099181
1100	1210000	1331000000	33·1662479	10·3228012	·0009090909
1101	1212201	1334633301	33·1813200	10·3259284	·0009082652
1102	1214404	1338273208	33·1963853	10·3290537	·0009074410
1103	1216609	1341919727	33·2114438	10·3321770	·0009066183
1104	1218816	1345572864	33·2266955	10·3352985	·0009057971
1105	1221025	1349232625	33·2415403	10·3384181	·0009049774
1106	1223236	1352899016	33·2565783	10·3415358	·0009041591
1107	1225449	1356572043	33·2716095	10·3446517	·0009033424
1108	1227664	1360251712	33·2866339	10·3477657	·0009025271
1109	1229881	1363938029	33·3016516	10·3508778	·0009017133
1110	1232100	1367631000	33·3166625	10·3539880	·0009009009
1111	1234321	1371330631	33·3316666	10·3570964	·0009000900
1112	1236544	1375036928	33·3466640	10·3602029	·0008992806
1113	1238769	1378749897	33·3616546	10·3633076	·0008984726
1114	1240996	1382469544	33·3766385	10·3664103	·0008976661
1115	1243225	1386195875	33·3916157	10·3695113	·0008968610
1116	1245456	1389928896	33·4065862	10·3726103	·0008960753
1117	1247689	1393668613	33·4215499	10·3757076	·0008952551
1118	1249924	1397415032	33·4365070	10·3788030	·0008944544
1119	1252161	1401168159	33·4514573	10·3818965	·0008936550
1120	1254400	1404928000	33·4664011	10·3849882	·0008928571
1121	1256641	1408694561	33·4813381	10·3880781	·0008920607
1122	1258884	1412467848	33·4962684	10·3911661	·0008912656
1123	1261129	1416247867	33·5111921	10·3942527	·0008904720
1124	1263376	1420034624	33·5261092	10·3973366	·0008896797
1125	1265625	1423828125	33·5410196	10·4004192	·0008888889
1126	1267876	1427628376	33·5559234	10·4034999	·0008880995
1127	1270129	1431435383	33·5708206	10·4065787	·0008873114
1128	1272384	1435249152	33·5857112	10·4096557	·0008865248
1129	1274641	1439069689	33·6005952	10·4127310	·0008857396
1130	1276900	1442897000	33·6154726	10·4158044	·0008849558
1131	1279161	1446731091	33·6303434	10·4188760	·0008841733
1132	1281424	1450571968	33·6452077	10·4219458	·0008833922
1133	1283689	1454419637	33·6600653	10·4250138	·0008826125
1134	1285956	1458274104	33·6749165	10·4280800	·0008818342
1135	1288225	1462135375	33·6897610	10·4311443	·0008810573
1136	1290496	1466003456	33·7045991	10·4342069	·0008802817
1137	1292769	1469878353	33·7174306	10·4372677	·0008795075
1138	1295044	1473760072	33·7340556	10·4403677	·0008787346
1139	1297321	1477648619	33·7490741	10·4433839	·0008779631
1140	1299600	1481544000	33·7638860	10·4464393	·0008771930
1141	1301881	1485446221	33·7786915	10·4494929	·0008764242
1142	1304164	1489355288	33·7934905	10·4525448	·0008756567
1143	1306449	1493271207	33·8082830	10·4555948	·0008748906
1144	1308736	1497193984	33·8230691	10·4586431	·0008741259
1145	1311025	1501123625	33·8378486	10·4616896	·0008733624
1146	1313316	1505060136	33·8526218	10·4647343	·0008726003
1147	*1315609*	1509003523	33·8673884	10·4677773	·0008718396

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
1148	1317904	1512953792	33·8821487	10·4708158	·0008710801
1149	1320201	1516910949	33·8969025	10·4738579	·0008703220
1150	1322500	1520875000	33·9116499	10·4768955	·0008695652
1151	1324801	1524845951	33·9263909	10·4799314	·0008688097
1152	1327104	1528823808	33·9411255	10·4829656	·0008680556
1153	1329409	1532808577	33·9558537	10·4859980	·0008673027
1154	1331716	1536800264	33·9705755	10·4890286	·0008665511
1155	1334025	1540798875	33·9852910	10·4920575	·0008658009
1156	1336336	1544804416	34·0000000	10·4950847	·0008650519
1157	1338649	1548816893	34·0147027	10·4981101	·0008643042
1158	1340964	1552836312	34·0293990	10 5011337	·0008635579
1159	1343281	1556862679	34·0440890	10·5041556	·0008628128
1160	1345600	1560896000	34·0587727	10·5071757	·0008620690
1161	1347921	1564936281	34·0734501	10·5101942	·0008613244
1162	1350244	1568983528	34·0881211	10·5132109	·0008605852
1163	1352569	1573037747	34·1027858	10·5162259	·0008598452
1164	1354896	1577098944	34·1174442	10·5192391	·0008591065
1165	1357225	1581167125	34·1320963	10·5222506	·0008583691
1166	1359556	1585242296	34·1467422	10·5252604	·0008576329
1167	1361889	1589324463	34·1613817	10·5282685	·0008568980
1168	1364224	1593413632	34·1760150	10·5312749	·0008561644
1169	1366561	1597509809	34·1906420	10·5342795	·0008554320
1170	1368900	1601613000	34·2052627	10·5372825	·0008547009
1171	1371241	1605723211	34·2198773	10·5402837	·0008539710
1172	1373584	1609840448	34·2344855	10·5432832	·0008532423
1173	1375929	1613964717	34·2490875	10·5462810	·0008525149
1174	1378276	1618096024	34·2636834	10·5492771	·0008517888
1175	1380625	1622234375	34·2782730	10·5522715	·0008510638
1176	1382976	1626379776	34·2928564	10·5552642	·0008503401
1177	1385329	1630532233	34·3074336	10·5582552	·0008496177
1178	1387684	1634691752	34·3220046	10·5612445	·0008488964
1179	1390041	1638858339	34·3365694	10·5642322	·0008481764
1180	1392400	1643032000	34·3511281	10·5672181	·0008471576
1181	1394761	1647212741	34·3656805	10·5702024	·0008467401
1182	1397124	1651400568	34·3802268	10·5731849	·0008460237
1183	1399489	1655595487	34·3947670	10·5761658	·0008453085
1184	1401856	1659797504	34·4093011	10·5791449	·0008445946
1185	1404225	1664006625	34·4238289	10·5821215	·0008438819
1186	1406596	1668222856	34·4383507	10·5850983	·0008431703
1187	1408969	1672446203	34·4528663	10·5880725	·0008424600
1188	1411344	1676676672	34·4673759	10 5910450	·0008417508
1189	1413721	1680914269	34·4818793	10·5940158	·0008410429
1190	1416100	1685159000	34·4963766	10·5969850	·0008403361
1191	1418481	1689410871	34·5108678	10·5999525	·0008396306
1192	1420864	1693669888	34·5253530	10·6029184	·0008389262
1193	1423249	1697936057	34·5398321	10·6058826	·0008382320
1194	1425636	1702209384	34·5543051	10·6088451	·0008375209
1195	1428025	1706489875	34·5687720	10 6118060	·0008368201
1196	1430416	1710777536	34·5832329	10·6147652	·0008361204
1197	1432809	1715072373	34·5976879	10·6177228	·0008354219
1198	1435204	1719374392	34·6121366	10 6206788	·0008347245
1199	1437601	1723683599	34·6265794	10·6236331	·0008340284
1200	1440000	1728000000	34·6410162	10·6265857	·0008333333
1201	1442401	1732323601	34·6554469	10·6295367	·0008326395
1202	1444804	1736654408	34·6698716	10·6324860	·0008319468
1203	1447209	1740992427	34·6842904	10·6354338	·0008312552
1204	1449616	1745337664	34·6987031	10·6383799	·0008305648
1205	1452025	1749690125	34·7131099	10·6413244	·0008298755
1206	1454436	1754049816	34·7275107	10·6442672	·0008291874
1207	1456849	1758416743	34·7419055	10·6472085	·0008285004
1208	1459264	1762790912	34·7562944	10·6501480	·0008278146
1209	1461681	1767172329	34·7706773	10·6530860	·0008271299
1210	1464100	1771561000	34·7850543	10·6560223	·0008264463
1211	1466521	1775956931	34·7994253	10·6589570	·0008257638

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals
1212	1468944	1780360128	34·8137904	10·6618902	·0008250825
1213	1471369	1784770597	34·8281495	10·6648217	·0008244023
1214	1473796	1789188344	34·8425028	10·6677516	·0008237232
1215	1476225	1793613375	34·8568501	10·6706799	·0008230453
1216	1478656	1798045696	34·8711915	10·6736086	·0008223684
1217	1481089	1802485313	34·8855271	10·6765317	·0008216927
1218	1483524	1806932232	34·8998567	10·6794552	·0008210181
1219	1485961	1811386459	34·9141805	10·6823771	·0008203445
1220	1488400	1815848000	34·9284984	10·6852978	·0008196721
1221	1490841	1820316861	34·9428104	10·6882160	·0008190008
1222	1493284	1824793048	34·9571166	10·6911331	·0008183306
1223	1495729	1829276567	34·9714169	10·6940486	·0008176615
1224	1498176	1833767424	34·9857114	10·6969625	·0008169935
1225	1500625	1838265625	35·0000000	10·6998748	·0008163265
1226	1503076	1842771176	35·0142828	10·7027855	·0008156607
1227	1505529	1847284083	35·0285598	10·7056947	·0008149959
1228	1507984	1851804352	35·0428309	10·7086023	·0008143322
1229	1510441	1856331989	35·0570963	10·7115083	·0008136696
1230	1512900	1860867000	35·0713558	10·7144127	·0008130081
1231	1515361	1865409391	35·0856096	10·7173155	·0008123477
1232	1517824	1869959168	35·0998575	10·7202168	·0008116883
1233	1520289	1874516337	35·1140997	10·7231165	·0008110300
1234	1522756	1879080904	35·1283361	10·7260146	·0008103728
1235	1525225	1883652875	35·1425568	10·7289112	·0008097166
1236	1527696	1888232256	35·1567917	10 7318062	·0008090615
1237	1530169	1892819053	35·1710108	10·7346997	·0008084074
1238	1532644	1897413272	35·1852242	10·7375916	·0008077544
1239	1535121	1902014919	35·1994318	10·7404819	·0008071025
1240	1537600	1906624000	35·2136337	10·7433707	·0008064516
1241	1540081	1911240521	35·2278299	10·7462579	·0008058018
1242	1542564	1915864488	35·2420204	10·7491436	·0008051530
1243	1545049	1920495907	35·2562051	10·7520277	·0008045052
1244	1547536	1925134784	35·2703842	10·7549103	·0008038585
1245	1550025	1929781125	35·2845575	10·7577913	·0008032129
1246	1552516	1934434936	35·2987252	10·7606708	·0008025682
1247	1555009	1939096223	35·3128872	10·7635488	·0008019246
1248	1557504	1943764992	35·3270435	10·7664252	·0008012821
1249	1560001	1948441249	35·3411941	10·7693001	·0008006405
1250	1562500	1953125000	35·3553391	10·7721735	·0008000000
1251	1565001	1957816251	35·3694784	10·7750453	·0007993605
1252	1567504	1962515008	35·3836120	10·7779156	·0007987220
1253	1570009	1967221277	35·3977400	10·7807843	·0007980846
1254	1572516	1971935064	35·4118624	10·7836516	·0007974482
1255	1575025	1976656375	35·4259792	10·7865173	·0007968127
1256	1577536	1981385216	35·4400903	10·7893815	·0007961783
1257	1580049	1986121593	35·4541958	10·7922441	·0007955449
1258	1582564	1990865512	35·4682957	10·7951053	·0007949126
1259	1585081	1995616979	35·4823900	10·7979649	·0007942812
1260	1587600	2000376000	35·4964787	10·8008230	·0007936508
1261	1590121	2055142581	35·5105618	10·8036797	·0007930214
1262	1592644	2009916728	35·5246393	10·8065348	·0007923930
1263	1595166	2014698449	35·5387113	10·8093884	·0007917656
1264	1597696	2019487744	35·5527777	10·8122404	·0007911392
1265	1600225	2024284625	35·5668385	10·8150909	·0007905138
1266	1602756	2029089096	35·5808937	10·8179400	·0007898894
1267	1605289	2033901163	35·5949434	10·8207876	·0007892660
1268	1607824	2038720832	35·6089876	10·8236336	·0007886435
1269	1610361	2043548109	35·6230262	10·8264782	·0007880221
1270	1612900	2048383000	35 6370593	10·8293213	·0007874016
1271	1615441	2053225511	35·6510869	10·8321629	·0007867821
1272	1617984	2058075648	35·6651090	10·8350030	·0007861635
1273	1620529	2062933417	35·6791255	10·8378416	·0007855460
1274	1623076	2067798824	35·6931366	10 8406788	·0007849294
1275	*1625625*	2072671875	35·7071421	10·8435144	·0007843137

Numbers.	**Squares.**	**Cubes.**	**Square Roots.**	**Cube Roots.**	**Reciprocals.**
1276	1628176	2077552576	35·7211422	10·8463485	·0007836991
1277	1630729	2082440933	35·7351867	10·8491812	·0007830854
1278	1633284	2087336952	35·7491258	10·8520125	·0007824726
1279	1635841	2092240639	35·7631095	10·8548422	·0007818608
1280	1638400	2097152000	35·7770876	10·8576704	·0007812500
1281	1640961	2102071041	35·7910603	10·8604972	·0007806401
1282	1643524	2106997768	35·8050276	10·8633225	·0007800312
1283	1646089	2111932187	35·8189894	10·8661454	·0007794232
1284	1648656	2116874304	35·8329457	10·8689687	·0007788162
1285	1651225	2121824125	35·8468966	10·8717897	·0007782101
1286	1653796	2126781656	35·8608421	10·8746091	·0007776050
1287	1656369	2131746903	35·8747822	10 8774271	·0007770008
1288	1658944	2136719872	35 8887169	10·8802436	·0007763975
1289	1661521	2141700569	35·9026461	10·8830587	·0007757952
1290	1664100	2146689000	35 9165699	10·8858723	·0007751938
1291	1666681	2151685171	35·9304884	10·8886845	·0007745933
1292	1669264	2156689088	35·9444015	10·8914952	·0007739938
1293	1671849	2161700757	35·9583092	10·8943044	·0007733952
1294	1674436	2166720184	35·9722115	10·8971123	·0007727975
1295	1677025	2171747875	35·9861084	10·8999186	·0007722008
1296	1679616	2176782336	36·0000000	10·9027235	·0007716049
1297	1682209	2181825073	36·0138862	10·9055269	·0007710100
1298	1684804	2186875592	36·0277671	10·9083290	·0007704160
1299	1687401	2191933899	36·0416426	10·9111296	·0007698229
1300	1690000	2197000000	36·0555128	10·9139287	·0007692308
1301	1692601	2202073901	36·0693776	10·9167265	·0007686395
1302	1695204	2207155608	36·0832371	10·9195228	·0007680492
1303	1697809	2212245127	36·0970913	10·9223177	·0007674579
1304	1700416	2217342464	36·1109402	10 9251111	·0007668712
1305	1703025	2222447625	36·1.47837	10·9279031	·0007662835
1306	1705636	2227560616	36·1386220	10·9306937	·0007656968
1307	1708249	2232681443	36·1524550	10·9334829	·0007651109
1308	1710864	2237810112	36·1662826	10·9362706	·0007645260
1309	1713481	2242946629	36·1801050	10 9390569	·0007639419
1310	1716100	2248091000	36·1939221	10·9418418	·0007633588
1311	1718721	2253243231	36·2077340	10·9446253	·0007627765
1312	1721344	2258403328	36·2215406	10·9475074	·0007621951
1313	1723969	2263571297	36·2353419	10 9501880	·0007616446
1314	1726596	2268747144	36·2491379	10·9529673	·0007610350
1315	1729225	2273930875	36·2626287	10·9557451	·0007604563
1316	1731856	2279122496	36·2767143	10·9585215	·0007598784
1317	1734489	2284322013	36·2904246	10·9612965	·0007593014
1318	1737124	2289529432	36·3042697	10 9640701	·0007587253
1319	1739761	2294744759	36·3180396	10·9668423	·0007581501
1320	1742400	2299968000	36·3318042	10·9696131	·0007575758
1321	1745041	2305199161	36·3455637	10·9723825	·0007570023
1322	1747684	2310438248	36·3593179	10·9751505	·0007564297
1323	1750329	2315685267	36·3730670	10·9779171	·0007558579
1324	1752976	2320940224	36·3868108	10·9806823	·0007552870
1325	1755625	2326203125	36·4005494	10·9834462	·0007547170
1326	1758276	2331473976	36·4142829	10·9862086	·0007541478
1327	1760929	2336752783	36·4280112	10 9889696	·0007535795
1328	1763584	2342039552	36·4417343	10·9917293	·0007530120
1329	1766241	2347334289	36·4554523	10·9944876	·0007524454
1330	1768900	2352637000	36·4691650	10·9972445	·0007518797
1331	1771561	2357947691	36·4828727	11·0000000	·0007513148
1332	1774224	2363266368	36·4965752	11·0027541	·0007507508
1333	1776889	2368593037	36·5102725	11 0055069	·0007501875
1334	1779556	2373927704	36·5239647	11·0082583	·0007496252
1335	1782225	2379270375	36·5376518	11·0110082	·0007490637
1336	1784896	2384621056	36·5513388	11·0137569	·0007485030
1337	1787569	2389979753	36·5650106	11 0165041	·0007479432
1338	1790244	2395346472	36·5786823	11·0192500	·0007473842
1339	1792921	2400721219	36·5923489	11·0219945	·0007468260

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
1340	1795600	2406104000	36·6060104	11·0247377	·0007462687
1341	1798281	2411494821	36·6196668	11·0274795	·0007457122
1342	1800964	2416893688	36·6333181	11·0302199	·0007451565
1343	1803649	2422300607	36·6469144	11 0329590	·0007446016
1344	1806336	2427715584	36·6606056	11·0356967	·0007440476
1345	1809025	2433138625	36·6742416	11·0384330	·0007434944
1346	1811716	2438569736	36·6878726	11·0411680	·0007429421
1347	1814409	2444008923	36·7014986	11·0439017	·0007423905
1348	1817104	2449456192	36·7151195	11·0466339	·0007418398
1349	1819801	2454911549	36·7287353	11·0493649	·0007412898
1350	1822500	2460375000	36·7423461	11·0520945	·0007407407
1351	1825201	2465846551	36·7559519	11·0548227	·0007401924
1352	1827904	2471326208	36·7695526	11·0575497	·0007396450
1353	1830609	2476813977	36·7831483	11·0602752	·0007390983
1354	1833316	2482309864	36·7967390	11·0629994	·0007385524
1355	1836025	2487813875	36·8103246	11·0657222	·0007380074
1356	1838736	2493326016	36·8239053	11·0684437	·0007374631
1357	1841449	2498846293	36·8374809	11·0711639	·0007369197
1358	1844164	2504374712	36·8510515	11·0738828	·0007363770
1359	1846881	2509911279	36·8646172	11·0766003	·0007358352
1360	1849600	2515456000	36·8781778	11·0793165	·0007352941
1361	1852321	2521008881	36·8917335	11·0820314	·0007347539
1362	1855044	2526569928	36·9052842	11·0847449	·0007342144
1363	1857769	2532139147	36·9188299	11·0874571	·0007336757
1364	1860496	2537716544	36·9323706	11·0901679	·0007331378
1365	1863225	2543302125	36·9459064	11·0928775	·0007326007
1366	1865956	2548895896	36·9594372	11·0955857	·0007320644
1367	1868689	2554497863	36·9729631	11·0982926	·0007315289
1368	1871424	2560108032	36·9864840	11·1009982	·0007309942
1369	1874161	2565726409	37·0000000	11·1037025	·0007304602
1370	1876900	2571353000	37·0135110	11·1064054	·0007299270
1371	1879641	2576987811	37·0270172	11·1091070	·0007293946
1372	1882384	2582630848	37·0405184	11·1118073	·0007288630
1373	1885129	2588282117	37·0540146	11·1145064	·0007283321
1374	1887876	2593941624	37·0675060	11·1172041	·0007278020
1375	1890625	2599609375	37·0899924	11·1199004	·0007272727
1376	1893376	2605285376	37 0944740	11·1225955	·0007267442
1377	1896129	2610969633	37·1079506	11 1252893	·0007262164
1378	1898884	2616662152	37·1214224	11·1279817	·0007256894
1379	1901641	2622362939	37·1348893	11·1306729	·0007251632
1380	1904400	2628072000	37·1483512	11·1333628	·0007246377
1381	1907161	2633789341	37·1618084	11·1360514	·0007241130
1382	1909924	2639514968	37·1752606	11·1387386	·0007235890
1383	1912689	2645248887	37·1887079	11·1414246	·0007230658
1384	1915456	2650991104	37·2021505	11·1441093	·0007225434
1385	1918225	2656741625	37·2155881	11·1467926	·0007220217
1386	1920996	2662500456	37·2290209	11·1494747	·0007215007
1387	1923769	2668267603	37·2424489	11·1521555	·0007209805
1388	1926544	2674043072	37·2558720	11·1548350	·0007204611
1389	1929321	2679826869	37·2692903	11·1575133	·0007199424
1390	1932100	2685619000	37·2827037	11·1601903	·0007194245
1391	1934881	2691419471	37·2961124	11·1628659	·0007189073
1392	1937664	2697228288	37·3095162	11·1655403	·0007183908
1393	1940449	2703045457	37·3229152	11·1682134	·0007178751
1394	1943236	2708870984	37·3363094	11·1708852	·0007173601
1395	1946025	2714704875	37·3496988	11·1735558	·0007168459
1396	1948816	2720547136	37·3630834	11·1762250	·0007163324
1397	1951609	2726397773	37·3764632	11·1788930	·0007158196
1398	1954404	2732256792	37·3898382	11·1815598	·0007153076
1399	1957201	2738124199	37 4032084	11·1842252	·0007147963
1400	1960000	2744000000	37·4165738	11·1868894	·0007142857
1401	1962801	2749884201	37·4299345	11·1895523	·0007137759
1402	1965604	2755776808	37·4432904	11·1922139	·0007132668
1403	*1968409*	2761677827	37·4566416	11·1948743	·0007127584

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
1404	1971216	2767587264	37·4699880	11·1975334	·0007122507
1405	1974025	2773505125	37·4833296	11·2001913	·0007117438
1406	1976836	2779431416	37·4966665	11·2028479	·0007112376
1407	1979649	2785366143	37·5099987	11·2055032	·0007107321
1408	1982464	2791309312	37·5233261	11·2081573	·0007102273
1409	1985281	2797260929	37·5366487	11·2108101	·0007097232
1410	1988100	2803221000	37·5499667	11·2134617	·0007092199
1411	1990921	2809189531	37·5632799	11·2161120	·0007087172
1412	1993744	2815166528	37·5765885	11·2187611	·0007082153
1413	1996569	2821151997	37·5898922	11·2214089	·0007077141
1414	1999396	2827145944	37·6031913	11·2240054	·0007072136
1415	2002225	2833148375	37·6164857	11·2267007	·0007067138
1416	2005056	2839159296	37·6297754	11·2293448	·0007062147
1417	2007889	2845178713	37·6430604	11·2319876	·0007057163
1418	2010724	2851206632	37·6563407	11·2346292	·0007052186
1419	2013561	2857243059	37·6696164	11·2372696	·0007047216
1420	2016400	2863288000	37·6828874	11·2399087	·0007042254
1421	2019241	2869341461	37·6961536	11·2425465	·0007037298
1422	2022084	2875403448	37·7094153	11·2451831	·0007032349
1423	2024929	2881473967	37·7226722	11·2478185	·0007027407
1424	2027776	2887553024	37·7359245	11·2504527	·0007022472
1425	2030625	2893640625	37·7491722	11·2530856	·0007017544
1426	2033476	2899736776	37·7624152	11·2557173	·0007012623
1427	2036329	2905841483	37·7756535	11·2583478	·0007007708
1428	2039184	2911954752	37·7888873	11·2609770	·0007002801
1429	2042041	2918076589	37·8021163	11·2636050	·0006997901
1430	2044900	2924207000	37·8153408	11·3662318	·0006993007
1431	2047761	2930345991	37·8285606	11·2688573	·0006988120
1432	2050624	2936493568	37·8417759	11·2714816	·0006983240
1433	2053489	2942649737	37·8549864	11·2741047	·0006978367
1434	2056356	2948814504	37·8681924	11 2767266	·0006973501
1435	2059225	2954987875	37·8813938	11·2793472	·0006968641
1436	2062096	2961169856	37·8945906	11·2819666	·0006963788
1437	2064969	2967360453	37·9077828	11·2845849	·0006958942
1438	2067844	2973559672	37·9209704	11·2872019	·0006954103
1439	2070721	2979767519	37·9341538	11·2898177	·0006949270
1440	2073600	2985984000	37·9473319	11·2924323	·0006944444
1441	2076481	2992209121	37·9605058	11·2950457	·0006939625
1442	2079364	3098442888	37·9736751	11·2976579	·0006934813
1443	2082249	3004685307	37·9868398	11·3002688	·0006930007
1444	2085136	3010936384	38·0000000	11·3028786	·0006925208
1445	2088025	3017196125	38 0131556	11·3054871	·0006920415
1446	2080916	3023464536	38·0263067	11·3080945	·0006915629
1447	2093809	3029741623	38·0394532	11·3107006	·0006910850
1448	2096704	3036027392	38·0525952	11·3133056	·0006906078
1449	2099601	3042321849	38 0657326	11·3159094	·0006901312
1450	2102500	3048625000	38·0788655	11·3185119	·0006896552
1451	2105401	3054936851	38·0919939	11·3211132	·0006891799
1452	2108304	3061257408	38·1051178	11·3237134	·0006887052
1453	2111209	3067586677	38·1182371	11·3263124	·0006882312
1454	2114116	3073924664	38 1313519	11·3289102	·0006877579
1455	2117025	3080271375	38·1444622	11·3315067	·0006872852
1456	2119936	3086626816	38·1575681	11·3341022	·0006868132
1457	2122849	3092990993	38·1706693	11·3366964	·0006863412
1458	2125764	3099363912	38·1837662	11·3392894	·0006858711
1459	2128681	3105745579	38·1968585	11·3418813	·0006854010
1460	2131600	3112136000	38·2099463	11·3444719	·0006849315
1461	2134521	3118535181	38·2230297	11·3470614	·0006844627
1462	2137444	3124943128	38·2361085	11 3496497	·0006839945
1463	2140369	3131359847	38·2491829	11·3522368	·0006835270
1464	2143296	3137785344	38·2622529	11·3548227	·0006830601
1465	2146225	3144219625	38·2753184	11·3574075	·0006825939
1466	2149156	3150662696	38·2883794	11·3599911	·0006821282
1467	2152089	3157114563	38·3014360	11·3625735	·0006816633

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
1468	2155024	3163575232	38·3144881	11·3651547	·0006811989
1469	2157961	3170044709	38·3275358	11·3677347	·0006807352
1470	2160900	3176523000	38·3405790	11·3703136	·0006802721
1471	2163841	3183010111	38·3536178	11·3728914	·0006798097
1472	2166784	3189506048	38·3666522	11·3754679	·0006793478
1473	2169729	3196010817	38·3796821	11·3780433	·0006788866
1474	2172676	3202524424	38·3927076	11·3806175	·0006784261
1475	2175625	3209046875	38·4057287	11·3831906	·0006779661
1476	2178576	3215578176	38·4187454	11·3857625	·0006775068
1477	2181529	3222118333	38·4317577	11·3883332	·0006770481
1478	2184484	3228667352	38·4447656	11·3909028	·0006765900
1479	2187441	3235225239	38·4577691	11·3934712	·0006761325
1480	2190400	3241792000	38·4707681	11·3960384	·0006756757
1481	2193361	3248367641	38·4837627	11·3986045	·0006752194
1482	2196324	3254952168	38·4967530	11·4011695	·0006747638
1483	2199289	3261545587	38·5097390	11·4037332	·0006743088
1484	2202256	3268147904	38·5227206	11·4062959	·0006738544
1485	2205225	3274759125	38·5356977	11·4088574	·0006734007
1486	2208196	3281379256	38·5486705	11·4114177	·0006729474
1487	2211169	3288008303	38·5616389	11·4139769	·0006724950
1488	2214144	3294646272	38·5746030	11·4165349	·0006720430
1489	2217121	3301293169	38·5875627	11·4190918	·0006715917
1490	2220100	3307949000	38·6005181	11·4206476	·0006711409
1491	2223081	3314613771	38·6134691	11·4242022	·0006706908
1492	2226064	3321287488	38·6264158	11·4267556	·0006702413
1493	2229049	3327970157	38·6393582	11·4293079	·0006697924
1494	2232036	3334661784	38·6522962	11·4318591	·0006693440
1495	2235025	3341362375	38·6652299	11·4344092	·0006688963
1496	2238016	3348071936	38·6781593	11·4369581	·0006684492
1497	2241009	3354790473	38·6910843	11·4395059	·0006680027
1498	2244004	3361517992	38·7040050	11·4420525	·0006675567
1499	2247001	3368254499	38·7169214	11·4445980	·0006671114
1500	2250000	3375000000	38·7298335	11·4471424	·0006666667
1501	2253001	3381754501	38·7427412	11·4496857	·0006662225
1502	2256004	3388518008	38·7556447	11·4522278	·0006657790
1503	2259009	3395290527	38·7685439	11·4547688	·0006653360
1504	2262016	3402072064	38·7814389	11·4573087	·0006648936
1505	2265025	3408862625	38·7943294	11·4598476	·0006644518
1506	2268036	3415662216	38·8072158	11·4623850	·0006640106
1507	2271049	3422470843	38·8200978	11·4649215	·0006635700
1508	2274064	3429288512	38·8329757	11·4674568	·0006631300
1509	2277081	3436115229	38·8458491	11·4699911	·0006626905
1510	2280100	3442951000	38·8587184	11·4725242	·0006622517
1511	2283121	3449795831	38·8715834	11·4750562	·0006618134
1512	2286144	3456649728	38·8844442	11·4775871	·0006613757
1513	2289169	3463512697	38·8973006	11·4801169	·0006609385
1514	2292196	3470384744	38·9101529	11·4826455	·0006605020
1515	2295225	3477265875	38·9230009	11·4851731	·0006600660
1516	2298256	3484156096	38·9358447	11·4876995	·0006596306
1517	2301289	3491055413	38·9486841	11·4902249	·0006591958
1518	2304324	3597963832	38·9615194	11·4927491	·0006587615
1519	2307361	3504881359	38·9743505	11·4952722	·0006583278
1520	2310400	3511808000	38·9871774	11·4977942	·0006578947
1521	2313441	3518743761	39·0000000	11·5003151	·0006574622
1522	2316484	3525688648	39·0128184	11·5028348	·0006570302
1523	2319529	3532642667	39·0256326	11·5053535	·0006565988
1524	2322576	3539605824	39·0384426	11·5078711	·0006561680
1525	2325625	3546578125	39·0512483	11·5103876	·0006557377
1526	2328676	3553559576	39·0640499	11·5129030	·0006553080
1527	2331729	3560550183	39·0768478	11·5154173	·0006548788
1528	2334784	3567549952	39·0896406	11·5179305	·0006544503
1529	2337841	3574558889	39·1024296	11·5204425	·0006540222
1530	2340900	3581577000	39·1152144	11·5229535	·0006535948
1531	2343961	3588604291	39·1279951	11·5254634	·0006531679

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals
1532	2347024	3595640768	39·1407716	11·5279722	·0006527415
1533	2350089	3602686437	39·1535439	11·5304799	·0006523157
1534	2353156	3609741304	39·1663120	11·5329865	·0006518905
1535	2356225	3616805375	39·1790760	11·5354920	·0006514658
1536	2359296	3623878656	39·1918359	11·5379965	·0006510417
1537	2362369	3630961153	39·2045915	11·5404998	·0006506181
1538	2365444	3638052872	39·2173431	11·5430021	·0006501951
1539	2368521	3645153819	39·2300905	11·5455033	·0006497726
1540	2371600	3652264000	39·2428337	11·5480034	·0006493506
1541	2374681	3659383421	39·2555728	11·5505025	·0006489293
1542	2377764	3666512088	39·2683078	11·5530004	·0006485084
1543	2380849	3673650007	39·2810387	11·5554972	·0006480881
1544	2383936	3680797184	39·2937654	11·5579931	·0006476684
1545	2387025	3687953625	39·3064880	11·5604878	·0006472492
1546	2390116	3695119336	39·3192065	11·5629815	·0006468305
1547	2393209	3702294323	39·3319208	11·5654740	·0006464124
1548	2396304	3709478592	39·3446311	11·5679655	·0006459948
1549	2399401	3716672149	39·3573373	11·5704559	·0006455778
1550	2402500	3723875000	39·3700394	11·5729453	·0006451613
1551	2405601	3731087151	39·3827373	11·5754336	·0006447453
1552	2408704	3738308608	39·3954312	11·5779208	·0006443299
1553	2411809	3745539377	39·4081210	11·5804069	·0006439150
1554	2414916	3752779464	39·4208067	11·5828919	·0006435006
1555	2418025	3760028875	39·4334883	11·5853759	·0006430868
1556	2421136	3767287616	39·4461658	11·5878588	·0006426735
1557	2424249	3774555693	39·4588393	11·5903407	·0006422608
1558	2427364	3781833112	39·4715087	11·5928215	·0006418485
1559	2430481	3789119879	39·4841740	11·5953013	·0006414368
1560	2433600	3796416000	39·4968353	11·5977799	·0006410256
1561	2436721	3803721481	39·5094925	11·6002576	·0006406150
1562	2439844	3811036328	39·5221457	11·6027342	·0006402049
1563	2442969	3818360547	39·5347948	11·6052097	·0006397953
1564	2446096	3825694144	39·5474399	11·6076841	·0006393862
1565	2449225	3833037125	39·5600809	11·6101575	·0006389776
1566	2452356	3840389496	39·5727179	11·6126299	·0006385696
1567	2455489	3847751263	39·5853508	11·6151012	·0006381621
1568	2458624	3855122432	39·5979797	11·6175715	·0006377551
1569	2461761	3862503009	39·6106046	11·6200407	·0006373486
1570	2464900	3869883000	39·6232255	11·6225088	·0006369427
1571	2468041	3877292411	39·6358424	11·6249759	·0006365372
1572	2471184	3884701248	39·6484552	11·6274420	·0006361323
1573	2474329	3892119517	39·6610640	11·6299070	·0006357279
1574	2477476	3899547224	39·6736688	11·6323710	·0006353240
1575	2480625	3906984375	39·6862696	11·6348339	·0006349206
1576	2483776	3914430976	39·6988665	11·6372957	·0006345178
1577	2486929	3921887033	39·7114593	11·6397566	·0006341154
1578	2490084	3929352552	39·7240481	11·6422164	·0006337136
1579	2493241	3936827539	39 7366329	11·6446751	·0006333122
1580	2496400	3944312000	39·7492138	11·6471329	·0006329114
1581	2499561	3951805941	39·7617907	11·6495895	·0006325111
1582	2502724	3959309368	39·7743636	11·6520452	·0006321113
1583	2505889	3966822287	39·7869325	11·6544998	·0006317119
1584	2509056	3974344704	39·7994976	11·6569534	·0006313131
1585	2512225	3981876625	39·8120585	11·6594059	·0006309148
1586	2515396	3989418056	39·8246155	11·6618574	·0006305170
1587	2518569	3996969003	39·8371686	11·6643079	·0006301197
1588	2521744	4004529472	39·8497177	11·6667574	·0006297229
1589	2524921	4012099469	39·8622628	11·6692058	·0006293266
1590	2528100	4014679000	39·8748040	11·6716532	·0006289308
1591	2531281	4027268071	39·8873413	11·6740996	·0006285355
1592	2534464	4034866688	39·8998747	11·6765449	·0006281407
1593	2537649	4042474857	39·9124041	11·6789892	·0006277464
1594	2540836	4950092584	39·9249295	11·6814325	·0006273526
1595	2544025	4057719875	39·9374511	11·6838748	·0006269592

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
1596	2547216	4065356736	39·9499687	11·6863161	·0006265664
1597	2550409	4073003173	39·9624824	11·6887563	·0006261741
1598	2553604	4080659192	39·9749922	11·6911955	·0006257822
1599	2556801	4088324799	39·9874980	11·6936337	·0006253909
1600	2560000	4096000000	40·0000000	11·6960709	·0006250000

To Find the Square or Cube Root of a Number consisting of Integers and Decimals.

Multiply the difference between the root of the integer part of the given number, and the root of the next higher integer number, by the decimal part of the given number, and add the product to the root of the given integer number; the sum is the root required.

EXAMPLE.—Required the square root of 20·321.

Square root of 21 = 4·5825
Do. 20 = 4·4721

·1104 × ·321 + 4·4721 = 4·5075384, the square root required.

Required the cube root of 16·42.

Cube root of 17 = 2·5712
Do. 16 = 2·5198

·0514 × ·42 + 2·5198 = 2·541388, the cube root required.

TABLE OF THE FOURTH AND FIFTH POWERS OF NUMBERS.

Number.	4th Power.	5th Power.	Number.	4th Power.	5th Power.
1	1	1	18	104976	1889568
2	16	32	19	130321	2476099
3	81	243	20	160000	3200000
4	256	1024	21	194481	4084101
5	625	3125	22	234256	5153632
6	1296	7776	23	279841	6436343
7	2401	16807	24	331776	7962624
8	4096	32768	25	390625	9765625
9	6561	59049	26	456976	11881376
10	10000	100000	27	531441	14348907
11	14641	161051	28	614665	17210368
12	20736	248832	29	707281	20511149
13	28561	371293	30	810000	24300000
14	38416	537824	31	923521	28629151
15	50625	759375	32	1048576	33554432
16	65536	1048576	33	1185921	39135393
17	83521	1419857	34	1336336	45435424

Number.	4th Power.	5th Power.	Number.	4th Power.	5th Power.
35	1500625	52521875	93	74805201	6596883693
36	1679616	60466176	94	78074896	7339040224
37	1874161	69343957	95	81450625	7737809375
38	2085136	79235168	96	84934656	8153726976
39	2313441	90224199	97	88529281	8587340257
40	2560000	102400000	98	92236816	9039207968
41	2825761	115856201	99	96059601	9509900490
42	3111696	130691232	100	100000000	10000000009
43	3418801	147008443	101	104060401	10510100501
44	3748096	164916224	102	108243216	11040808032
45	4100625	184528125	103	112550881	11592740743
46	4477456	205962976	104	116985856	12166529024
47	4879681	229345007	105	121550625	12762815625
48	5308416	254803968	106	126247696	13382255776
49	5764801	282475249	107	131079601	14025517307
50	6250000	312500000	108	136048896	14693280768
51	6765201	345025251	109	141158161	15386239549
52	7311616	380204032	110	146410000	16105100000
53	7890481	418195493	111	151807041	16850591551
54	8503056	459165024	112	157351936	17623416832
55	9150625	503284375	113	163047361	18424351793
56	9834496	550731776	114	168896016	19254145824
57	10556001	601692057	115	174900625	20113571875
58	11316496	656356768	116	181063936	21003416576
59	12117361	714924299	117	187388721	21924480357
60	12960000	777600000	118	193877776	22877577568
61	13845841	844596301	119	200533921	23863536599
62	14776336	916132832	120	207360000	24883200000
63	15752961	992436543	121	214358881	25937424601
64	16777216	1073741824	122	221533456	27027081632
65	17850625	1160290625	123	228886641	28153056843
66	18974736	1252332576	124	236421376	29316250624
67	20151121	1350125107	125	244140625	30517578125
68	21381376	1453933568	126	252047376	31757969376
69	22667121	1564031349	127	260144641	33038369407
70	24010000	1680700000	128	268435456	34359738368
71	25411681	1804229351	129	276922881	35723051649
72	26873856	1934917632	130	285610000	37129300000
73	28398241	2073071593	131	294499921	38579489651
74	29986576	2219006624	132	303595776	40074642432
75	31640625	2373046875	133	312900721	41615795893
76	33362176	2535525376	134	322417936	43204003424
77	35153041	2706784157	135	332150625	44840334375
78	37015056	2887174368	136	342102016	56525874176
79	38950081	3077056399	137	352275361	48261724457
80	40960000	3276800000	138	362673936	50049003168
81	43046721	3486784401	139	373301641	51888844699
82	45212176	3707398439	140	384160000	53782400000
83	47458321	3939040643	141	395254161	55730836701
84	49787136	4182119424	142	406586896	57735339232
85	52200625	4437053125	143	418161601	59797108943
86	54708016	4704270176	144	429981696	61917364224
87	57289761	4984209207	145	442050625	64097340625
88	59969536	5277319168	146	454371856	66338290976
89	62742241	5584059449	147	466948881	68641485507
90	65610000	5904900000	148	479785216	71008211968
91	68574961	6240321451	149	492884401	73439775749
92	71639296	6590815232	150	506250000	75937500000

Diam.	Circumference.	Area.	Side of Equal Square.	Diam.	Circumference.	Area.	Side of Equal Square.
57¾	181·427	2619·35	51·178	73	229·336	4185·39	64·692
58	182·212	2642·08	51·399	73¼	230·122	4214·11	64·914
58¼	182·998	2664·91	51·621	73½	230·907	4242·92	65·135
58½	183·783	2687·83	51·842	73¾	231·693	4271·83	65·357
58¾	184·569	2710·85	52·064	74	232·478	4300·85	65·578
59	185·354	2733·97	52·285	74¼	233·263	4329·95	65·800
59¼	186·139	2757·19	52·507	74½	234·049	4359·16	66·022
59½	186·925	2780·51	52·729	74¾	234·834	4388·47	66·243
59¾	187·710	2803·92	52·950	75	235·620	4417·87	66·465
60	188·496	2827·44	53·172	75¼	236·405	4447·37	66·686
60¼	189·281	2851·05	53·393	75½	237·190	4476·97	66·908
60½	190·066	2874·76	53·615	75¾	237·976	4506·67	67·129
60¾	190·852	2898·56	53·836	76	238·761	4536·47	67·351
61	191·637	2922·47	54·048	76¼	239·547	4566·36	67·572
61¼	192·423	2946·47	54·279	76½	240·332	4596·35	67·794
61½	193·208	2970·57	54·501	76¾	241·117	4626·44	68·016
61¾	193·993	2994·77	54·723	77	241·903	4656·63	68·237
62	194·779	3019·07	54·944	77¼	242·688	4686·92	68·459
62¼	195·564	3043·47	55·166	77½	243·474	4717·30	68·680
62½	196·350	3067·96	55·387	77¾	244·259	4747·79	68·902
62¾	197·135	3092·56	55·609	78	245·044	4778·37	69·123
63	197·920	3117·25	55·830	78¼	245·830	4809·05	69·345
63¼	198·706	3142·04	56·052	78½	246·615	4839·83	69·566
63½	199·491	3166·92	56·273	78¾	247·401	4870·70	69·788
63¾	200·277	3191·91	56·495	79	248·186	4901·68	70·009
64	201·062	3216·99	56·716	79¼	248·971	4932·75	70·231
64¼	201·847	3242·17	56·938	79½	249·757	4963·92	70·453
64½	202·633	3267·46	57·159	79¾	250·542	4995·19	70·674
64¾	203·418	3292·83	57·381	80	251·328	5026·56	70·896
65	204·204	3318·31	57·603	80¼	252·113	5058·01	71·119
65¼	204·989	3343·88	57·824	80½	252·898	5089·58	71·339
65½	205·774	3369·56	58·046	80¾	253·684	5121·24	71·562
65¾	206·560	3395·33	58·267	81	254·469	5153·00	71·782
66	207·345	3421·20	58·489	81¼	255·255	5184·86	72·005
66¼	208·131	3447·16	58·710	81½	256·040	5216·82	72·226
66½	208·916	3473·23	58·932	81¾	256·825	5248·87	72·449
66¾	209·701	3499·39	59·154	82	257·611	5281·02	72·668
67	210·487	3525·66	59·375	82¼	258·396	5313·27	72·892
67¼	211·272	3552·01	59·597	82½	259·182	5345·62	73·111
67½	212·058	3578·47	59·818	82¾	259·967	5370·07	73·335
67¾	212·843	3605·03	60·040	83	260·752	5410·62	73·554
68	213·628	3631·68	60·261	83¼	261·538	5443·26	73·778
68¼	214·414	3658·44	60·483	83½	262·323	5476·00	73·997
68½	215·199	3685·29	60·704	83¾	263·109	5508·84	74·221
68¾	215·985	3712·24	60·926	84	263·894	5541·78	74·440
69	216·770	3739·28	61·147	84¼	264·679	5574·81	74·664
69¼	217·555	3766·43	61·369	84½	265·465	5607·95	74·884
69½	218·341	3793·67	61·591	84¾	266·250	5641·18	75·107
69¾	219·126	3821·02	61·812	85	267·036	5674·51	75·327
70	219·912	3848·46	62·034	85¼	267·821	5707·94	75·550
70¼	220·697	3875·99	62·255	85½	268·606	5741·47	75·770
70½	221·482	3903·63	62·477	85¾	269·392	5775·09	75·994
70¾	222·268	3931·36	62·698	86	270·177	5808·81	76·213
71	223·053	3959·20	62·920	86¼	270·963	5842·63	76·437
71¼	223·839	3987·13	63·141	86½	271·748	5876·55	76·656
71½	224·624	4015·16	63·363	86¾	272·533	5910·57	76·880
71¾	225·409	4043·28	63·545	87	273·319	5944·69	77·099
72	226·195	4071·51	63·806	87¼	274·104	5978·90	77·323
72¼	226·980	4099·83	64·028	87½	274·890	6013·21	77·542
72½	227·766	4128·25	64·249	87¾	275·675	6047·62	77·766
72¾	228·551	4156·77	64·471	88	276·460	6082·13	77·985

Diam.	Circumference.	Area.	Side of Equal Square.	Diam.	Circumference.	Area.	Side of Equal Square.
88¼	277·246	6116·74	78 209	100½	315·730	7932·73	89·065
88½	278·031	6151·44	78·428	100¾	316·516	7972 21	89·287
88¾	278·817	6186·25	78·652	101	317·301	8011·86	89·508
89	279·602	6221·15	78·871	101¼	318·087	8051·57	89·730
89¼	280·387	6256·15	79·095	101½	318·872	8091·38	89·952
89½	281·173	6291·25	79·315	101¾	319·657	8131·29	90·173
89¾	281·958	6326·44	79·538	102	320·443	8171·30	90·395
90	282·744	6361·74	79·758	102¼	321·228	8211·40	90·616
90¼	283·529	6397·13	79·982	102½	322·014	8251·60	90·838
90½	284·314	6432·62	80·201	102¾	322·799	8291·86	91·059
90¾	285·100	6468·21	80·425	103	323·584	8332·30	91·281
91	285·885	6503·89	80·644	103¼	324·370	8372·80	91 502
91¼	286·671	6539·68	80·868	103½	325·155	8413·40	91·724
91½	287·456	6573·56	81·087	103¾	325·941	8454·09	91·946
91¾	288·241	6611·54	81·311	104	326·726	8494·88	92·167
92	289·027	6647·62	81·530	104¼	327·511	8535·77	92·389
92¼	289·812	6683·80	81·754	104½	328·297	8576·76	92·610
92½	290·598	6720·07	81·973	104¾	329·082	8617·85	92·832
92¾	291·383	6756·45	82·197	105	329·868	8659·03	93·053
93	292·168	6792·92	82·416	105¼	330·653	8700·31	93·275
93¼	292·954	6829·49	82·640	105½	331·438	8741·69	93·496
93½	293·739	6866·16	82·859	105¾	332·224	8783·17	93·718
93¾	294·535	6902·92	83·083	106	333·009	8824·75	93·940
94	295·310	6939·79	83·302	106¼	333·794	8866·42	94·161
94¼	296·095	6976·75	83·526	106½	334·580	8908·20	94·383
94½	296·881	7013·81	83·746	106¾	335·365	8950·07	94·604
94¾	297·666	7050·97	83·970	107	336·151	8992·04	94·826
95	298·452	7088·23	84·189	107¼	336·936	9034·11	95·047
95¼	299·237	7125·58	84·413	107½	337·722	9076·27	95·269
95½	300·022	7163·04	84·632	107¾	338·506	9118·54	95·491
95¾	300·808	7200·59	84·856	108	339·292	9160·90	95·712
96	301·593	7238·24	85·077	108¼	340·077	9203·36	95·934
96¼	302·379	7275·99	85·299	108½	340·863	9245·92	96·155
96½	303·164	7313·84	85·520	108¾	341·648	9288·58	96·377
96¾	303·949	7351·78	85·742	109	342·434	9331·33	96·598
97	304·735	7389·82	85·964	109¼	343·219	9374·18	96·820
97¼	305·520	7427·96	86·185	109½	344·005	9417·14	97·041
97½	306·306	7466·20	86·407	109¾	344·789	9460·19	97·263
97¾	307·091	7504·54	86·628	110	345·576	9503·34	97·485
98	307·876	7542·98	86·850	120	376·992	11309·76	106·348
98¼	308·662	7581·51	87·071	130	408·408	13273·26	115·234
98½	309·447	7620·14	87·293	140	439·824	15393·84	124·079
98¾	310·233	7658·87	87·514	150	471·240	17671·50	132·935
99	311·018	7697·70	87·736	160	502·656	20106·24	141·796
99¼	311·803	7736·62	87·958	170	534·072	22698·06	150·659
99½	312·589	7775·65	88·179	180	565·488	25446·96	159·521
99¾	313·374	7814·79	88·401	190	596·904	28352 94	168·383
100	314·160	7854·00	88·622	200	628·320	31416·00	177·247
100¼	314·945	7893·31	88·844	300	942·480	70686·00	265·869

WEIGHTS AND MEASURES.

Troy Weight.

Pound.		Ounces.		Pennyweights.		Grains.	gr.
				1	=	24	dwt.
		1	=	20	=	480	oz.
1	=	12	=	240	=	5760	lb.

A carat = 4 grains.
437·5 grs. troy = 1 oz. avoirdupois.
7000 „ = 1 lb. „
100 ozs. troy = 109$\frac{5}{7}$ ozs. avoirdupois.
3·2 grs. troy = 4 diamond grs.
1 oz. „ = 150 „

The pound troy is the weight of 22·815 cubic inches of distilled water, at the temperature of 62° Fahr., the height of the barometer being 30 inches.

Troy weight is used in philosophical experiments, and in weighing gold, silver, and jewels. The fineness of gold and silver coins means the proportion of the precious metal which they contain. This is expressed in 1000ths of their total weight, or in carats—24ths of their total weight. British gold coins are 22 carats fine, or 0·916$\frac{2}{3}$; silver coins, 0·925. Gold, if pure, is said to be 24 carats fine; if there be one of alloy, with 23 carats of pure gold, it is 23 carats fine, and so on downwards. The alloy in gold and silver coins consists of copper. The true weight of a sovereign is 123·274 grs., consisting of—pure gold, 11 parts, or 113·001 grs.; copper, 1 part, or 10·273 grs. Silver coin consists of—pure silver, 222 parts; copper, 18 parts. The weight of a shilling is 87$\frac{1}{4}$ grains. 24 pence are made from an avoirdupois pound of copper.

Apothecaries Weight.

Pound.		Ounces.		Drams, or Drachms.		Scruples.		Grains.	gr.
						1	=	20	scr.
				1	=	3	=	60	dr.
		1	=	8	=	24	=	480	oz.
1	=	12	=	96	=	288	=	5760	lb.

The sign of the scruple is ℈; the dram, ʒ; the ounce, ℥.

This weight, which is now abolished, was formerly used for *compounding* medicines. The grain, ounce, and pound are equal to those of troy weight.

Avoirdupois Weight.

Ton.		Cwts.		Quarters.		Stones.		Pounds.		Ounces.		Drams.	dr.
										1	=	16	oz.
								1	=	16	=	256	lb.
						1	=	14	=	224	=	3584	st.
				1	=	2	=	28	=	448	=	7168	qr.
		1	=	4	=	8	=	112	=	1792	=	28672	cwt.
1	=	20	=	80	=	160	=	2240	=	35840	=	573440	ton.

1 lb. avoirdupois = 7000 grains troy.
1 oz. avoirdupois = 437·5 grains troy.
100 oz. avoirdupois = 91$\frac{7}{48}$ths ozs. troy.

The imperial pound avoirdupois is the standard unit by means of which all commodities, except gold, silver, and precious stones, are weighed, and is equal to the weight of one-tenth of an imperial gallon, or of 27·7274 cubic inches of distilled water at the temperature of 62° Fahr., and when the barometer stands at 30 inches. A certain piece of platinum of this standard weight is kept in the Exchequer Office, at Westminster.

Lineal or Long Measure.

Mile.	Furlongs.	Chains.	Rods, Perches, or Poles.	Yards.	Feet.	Inches.
					1	12
				1	3	36
			1	5½	16½	198
		1	4	22	66	792
	1	10	40	220	660	7920
1	8	80	320	1760	5280	63360

1 link = 7·92 inches.
100 links = 1 chain, or 66 feet.
1 league = 3 geographical or nautical miles.
1 hand = 4 inches.
1 fathom = 6 feet.
1 military pace = 2½ feet.
1 geometrical pace = 5 feet.
1 geographical or nautical mile = 1·15 statute miles.
1 geographical degree = 60 geographical or nautical miles.
1 Admiralty knot = 6080 feet.

The yard is the imperial standard measure of length, and is the distance, at the temperature of 62° Fahr., between two marks on a certain bar kept in the Exchequer Office, Westminster.

Cloth Measure.

Ell.	Yard.	Quarters.	Nails.	Inches.
			1	2¼
		1	4	9
	1	4	16	36
1	1¼	5	20	45

The yard is the same as in Long Measure, but differs in its divisions and subdivisions.

Yarn Measure—Cotton.

Spindle.	Hanks.	Skeins.	Yards.
		1	120
	1	7	840
1	18	126	15120

Yarn Measure—Linen.

Spindle.	Hasps.	Hears.	Cuts.	Yards.
			1	300
		1	2	600
	1	6	12	3600
1	4	24	48	14400

2 8 2

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals
1468	2155024	3163575232	38·3144881	11·3651547	·0006811989
1469	2157961	3170044709	38·3275358	11·3677347	·0006807352
1470	2160900	3176523000	38·3405790	11·3703136	·0006802721
1471	2163841	3183010111	38·3536178	11·3728914	·0006798097
1472	2166784	3189506048	38·3666522	11·3754679	·0006793478
1473	2169729	3196010817	38·3796821	11·3780433	·0006788866
1474	2172676	3202524424	38·3927076	11·3806175	·0006784261
1475	2175625	3209046875	38·4057287	11·3831906	·0006779661
1476	2178576	3215578176	38·4187454	11·3857625	·0006775068
1477	2181529	3222118333	38·4317577	11·3883332	·0006770481
1478	2184484	3228667352	38·4447656	11·3909028	·0006765900
1479	2187441	3235225239	38·4577691	11·3934712	·0006761325
1480	2190400	3241792000	38·4707681	11·3960384	·0006756757
1481	2193361	3248367641	38·4837627	11·3986045	·0006752194
1482	2196324	3254952168	38·4967530	11·4011695	·0006747638
1483	2199289	3261545587	38 5097390	11·4037332	·0006743088
1484	2202256	3268147904	38·5227206	11·4062959	·0006738544
1485	2205225	3274759125	38·5356977	11·4088574	·0006734007
1486	2208196	3281379256	38·5486705	11·4114177	·0006729474
1487	2211169	3288008303	38·5616389	11·4139769	·0006724950
1488	2214144	3294646272	38·5746030	11·4165349	·0006720430
1489	2217121	3301293169	38·5875627	11·4190918	·0006715917
1490	2220100	3307949000	38·6005181	11·4206476	·0006711409
1491	2223081	3314613771	38·6134691	11·4242022	·0006706908
1492	2226064	3321287488	38·6264158	11·4267556	·0006702413
1493	2229049	3327970157	38·6393582	11·4293079	·0006697924
1494	2232036	3334661784	38·6522962	11·4318591	·0006693440
1495	2235025	3341362375	38·6652299	11·4344092	·0006688963
1496	2238016	3348071936	38·6781593	11·4369581	·0006684492
1497	2241009	3354790473	38·6910843	11·4395059	·0006680027
1498	2244004	3361517992	38·7040050	11·4420525	·0006675567
1499	2247001	3368254499	38·7169214	11·4445980	·0006671114
1500	2250000	3375000000	38·7298335	11·4471424	·0006666667
1501	2253001	3381754501	38·7427412	11·4496857	·0006662225
1502	2256004	3388518008	38·7556447	11·4522278	·0006657790
1503	2259009	3395290527	38·7685439	11·4547688	·0006653360
1504	2262016	3402072064	38·7814389	11·4573087	·0006648936
1505	2265025	3408862625	38·7943294	11·4598476	·0006644518
1506	2268036	3415662216	38·8072158	11·4623850	·0006640106
1507	2271049	3422470843	38·8200978	11·4649215	·0006635700
1508	2274064	3429288512	38·8329757	11·4674568	·0006631300
1509	2277081	3436115229	38·8458491	11·4699911	·0006626905
1510	2280100	3442951000	38·8587184	11·4725242	·0006622517
1511	2283121	3449795831	38·8715834	11·4750562	·0006618134
1512	2286144	3456649728	38·8844442	11·4775871	·0006613757
1513	2289169	3463512697	38·8973006	11·4801169	·0006609385
1514	2292196	3470384744	38·9101529	11·4826455	·0006605020
1515	2295225	3477265875	38·9230009	11·4851731	·0006600660
1516	2298256	3484156096	38·9358447	11·4876995	·0006596306
1517	2301289	3491055413	38·9486841	11·4902249	·0006591958
1518	2304324	3597963832	38·9615194	11·4927491	·0006587615
1519	2307361	3504881359	38·9743505	11·4952722	·0006583278
1520	2310400	3511808000	38·9871774	11·4977942	·0006578947
1521	2313441	3518743761	39·0000000	11·5003151	·0006574622
1522	2316484	3525688648	39·0128184	11·5028348	·0006570302
1523	2319529	3532642667	39·0256326	11·5053535	·0006565988
1524	2322576	3539605824	39·0384426	11·5078711	·0006561680
1525	2325625	3546578125	39·0512483	11·5103876	·0006557377
1526	2328676	3553559576	39·0640499	11·5129030	·0006553080
1527	2331729	3560550183	39·0768473	11·5154173	·0006548788
1528	2334784	3567549952	39·0896406	11·5179305	·0006544503
1529	2337841	3574558889	39·1024296	11·5204425	·0006540222
1530	2340900	3581577000	39·1152144	11·5229535	·0006535948
1531	*2343961*	3588604291	39·1279951	11 5254634	·0006531679

Numbers.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals
1532	2347024	3595640768	39·1407716	11·5279722	·0006527415
1533	2350089	3602686437	39·1535439	11·5304799	·0006523157
1534	2353156	3609741304	39·1663120	11·5329865	·0006518905
1535	2356225	3616805375	39·1790760	11·5354920	·0006514658
1536	2359296	3623878656	39·1918359	11·5379965	·0006510417
1537	2362369	3630961153	39·2045915	11·5404998	·0006506181
1538	2365444	3638052872	39·2173431	11·5430021	·0006501951
1539	2368521	3645153819	39·2300905	11·5455033	·0006497726
1540	2371600	3652264000	39·2428337	11·5480034	·0006493506
1541	2374681	3659383421	39·2555728	11·5505025	·0006489293
1542	2377764	3666512088	39·2683078	11·5530004	·0006485084
1543	2380849	3673650007	39·2810387	11·5554972	·0006480881
1544	2383936	3680797184	39·2937654	11·5579931	·0006476684
1545	2387025	3687953625	39·3064880	11·5604878	·0006472492
1546	2390116	3695119336	39·3192065	11·5629815	·0006468305
1547	2393209	3702294323	39·3319208	11·5654740	·0006464124
1548	2396304	3709478592	39·3446311	11·5679655	·0006459948
1549	2399401	3716672149	39·3573373	11·5704559	·0006455778
1550	2402500	3723875000	39·3700394	11·5729453	·0006451613
1551	2405601	3731087151	39·3827373	11·5754336	·0006447453
1552	2408704	3738308608	39·3954312	11·5779208	·0006443299
1553	2411809	3745539377	39·4081210	11·5804069	·0006439150
1554	2414916	3752779464	39·4208067	11·5828919	·0006435006
1555	2418025	3760028875	39·4334883	11·5853759	·0006430868
1556	2421136	3767287616	39·4461658	11·5878588	·0006426735
1557	2424249	3774555693	39·4588393	11·5903407	·0006422608
1558	2427364	3781833112	39·4715087	11·5928215	·0006418485
1559	2430481	3789119879	39·4841740	11·5953013	·0006414368
1560	2433600	3796416000	39·4968353	11·5977799	·0006410256
1561	2436721	3803721481	39·5094925	11·6002576	·0006406150
1562	2439844	3811036328	39·5221457	11·6027342	·0006402049
1563	2442969	3818360547	39·5347948	11·6052097	·0006397953
1564	2446096	3825694144	39·5474399	11·6076841	·0006393862
1565	2449225	3833037125	39·5600809	11·6101575	·0006389776
1566	2452356	3840389496	39·5727179	11·6126299	·0006385696
1567	2455489	3847751263	39·5853508	11·6151012	·0006381621
1568	2458624	3855122432	39·5979797	11·6175715	·0006377551
1569	2461761	3862503009	39·6106046	11·6200407	·0006373486
1570	2464900	3869893000	39·6232255	11·6225088	·0006369427
1571	2468041	3877292411	39·6358424	11·6249759	·0006365372
1572	2471184	3884701248	39·6484552	11·6274420	·0006361323
1573	2474329	3892119517	39·6610640	11·6299070	·0006357279
1574	2477476	3899547224	39·6736688	11·6323710	·0006353240
1575	2480625	3906984375	39·6862696	11·6348339	·0006349206
1576	2483776	3914430976	39·6988665	11·6372957	·0006345178
1577	2486929	3921887033	39·7114593	11·6397566	·0006341154
1578	2490084	3929352552	39·7240481	11·6422164	·0006337136
1579	2493241	3936827539	39 7366329	11·6446751	·0006333122
1580	2496400	3944312000	39·7492138	11·6471329	·0006329114
1581	2499561	3951805941	39·7617907	11·6495895	·0006325111
1582	2502724	3959309368	39·7743636	11·6520452	·0006321113
1583	2505889	3966822287	39·7869325	11·6544998	·0006317119
1584	2509056	3974344704	39·7994976	11·6569534	·0006313131
1585	2512225	3981876625	39·8120585	11·6594059	·0006309148
1586	2515396	3989418056	39·8246155	11·6618574	·0006305170
1587	2518569	3996969003	39·8371686	11·6643079	·0006301197
1588	2521744	4004529472	39·8497177	11·6667574	·0006297229
1589	2524921	4012099469	39·8622628	11·6692058	·0006293266
1590	2528100	4014679000	39·8748040	11·6716532	·0006289308
1591	2531281	4027268071	39·8873413	11·6740996	·0006285355
1592	2534464	4034866688	39·8998747	11·6765449	·0006281407
1593	2537649	4042474857	39·9124041	11·6789892	·0006277464
1594	2540836	4950092584	39·9249295	11·6814325	·0006273526
1595	2544025	4057719875	39·9374511	11·6838748	·0006269592

Ammoniacal liquor (*continued*).
    to convert Twaddel into specific gravity, 274.
    Twaddel's hydrometer, 274.
    Will's method of testing, 275.
Analysis of coals and cannels, 5 to 42.
    the ash of a good Newcastle coal, 4.
Analyzer, Aitken and Young's, 84.
Anderson's combined washer and scrubber, 96.
    exhauster, 89.
    tar furnace, 60.
    washer, 92.
Angle of repose of earths with horizontal line, 126.
Angles in mains, services, and internal fittings, 200.
Annual consumption of coal for gas purposes in the United Kingdom, 47.
Annual increase in gas consumption, usual, 301.
Annular atmospherical condenser, 79.
    Kirkham and Wright's, 80.
    Warner's, 80.
Annular or ring tanks, 125, 142.
Anthracite or glance coal, 1.
    weight per cubic yard, 46.
Apparatus required for testing meters, 211, 212.
    illuminating power, 244.
Approximate multipliers for facilitating calculations, 336.
Architectural and mechanical drawing, colours used in, 333
Area of coal measures in the United Kingdom, 5.
Area required for atmospherical condensation, 82.
Areas, &c., table of, 366.
Argand, Sugg's London, 248.
Arithmetical and algebraical signs, 335.
Arson (M.) on masonry tank walls, 130.
Ascension or stand pipes, 69.
    choking of, 69.
Ash in coal and coke, 4 to 42.
Ash pan, furnace, 58.
Ashes in mortar, 316.
Asphalt or tar mortar and concrete, 128, 129.
Atmospherical condensation, 82.
    annular condensers, 79.
    area required for, 82.
    atmospherical and water condensers combined, 81.
    Graham's condenser, 81.
    horizontal condensers, 80.

Aurum mosaicum, or gold bronze powder, 235.
Automatic pressure changer, Cowan's, 164.
Average yield of bituminous coal, 47.
Average meter system for public lighting, 207.
Axioms worth remembering, 198.

Balance and weights, experimental, 245.
Ball and socket joint for main pipes, 172.
Bar, graduated photometer, 245.
Bars, grate or fire, 57.
Barff-Bower process for protecting iron pipes and fittings, 199.
Barker's mill for distributing water in scrubbers, 95.
Barometer and thermometer used in testing illuminating power, 245
Battery or tubular condenser, 82.
Beale's exhauster, 89.
Beaumé's hydrometer, 276.
Bench, single and double retort, 49.
    clear space in front of, 50.
    flues and draught, 56.
Birmingham wire gauge, thickness of the, 319.
Bisulphide of carbon, 102, 103, 113, 282.
Bituminous coal, 1.
    average yield of, 47.
    weight per cubic yard, 46.
Blue or Bengal fire, 243.
Boiler and engine, steam, 90.
Bolts and nuts, 173.
Bond in brickwork, 309.
Books required in the keeping of a Gas Company's accounts, 327
Borders, illuminated, 242.
Bored and turned joints, for main pipes, 167, 168.
Box's retort-lid fastener, 65.
Box's table of the mean temperature of every tenth day, 78.
Brackets and chandeliers, height of, 228.
Braddock's station governor, 163.
Brass or iron, mixture for tinning, 234.
Brass tube, plain, weight per foot, 233.
    spiral and fluted, weight per foot, 233.
Brass work for lacquering, to clean, 237.
"Brasses" in coal, 48.
Bray's street lamps and burners, 206, 207.
    ventilating globe lights, 229.
Brazing, 234.

Breeze and coke, 270.
Bricks and brickwork, 308.
    bond in brickwork, 309.
    number of bricks in walls of different areas, 310.
    usual dimensions of bricks, 308.
Brick and puddle tanks, 125, 133.
Brick retorts and ovens, 54.
Brickwork in retort settings, 55.
Bridge and dip pipes, 69.
Bronze, 234.
    copper bronze powder, 235.
    gold bronze powders, or Aurum mosaicum, 235.
    green, 235.
    powders, 235.
    size for bronze powders, 235.
Brown or lignite coal, 1.
Buckstaves for retort bench, 51, 52.
Bunsen's photometer, 244.
Burner, "needle" governor, 230.
Burners, number required for lighting large buildings, 230.
    standard, 248.
    objections to horizontal, 228.
Bye pass mains and valves, 97.

Caking coal, 1.
Calcining spent lime, Hislop's process for, 101.
Calcium sulphide, purification by, 102.
Candle, standard sperm, 244.
    balance and weights, 245.
    corrections in consumption of, 247.
Cannel, 6.
    and coal nuts, and slack or dross, 43.
    and coals, analysis of, 5 to 42.
    weight of, per cubic yard, 46.
Capacity, gasholder, 145, 147.
    of coal stores, 47.
    of tar and liquor well, 98.
Capital of gas works, 301.
Carbon in coal, 3.
    in coal gas, 282.
    in retorts, deposition of, 62.
Carbonic acid, test for, 111, 115.
Carboniferous series, 2.

- Carbonizing, fuel for, 59.
- Carburetting condensers, 84.
- Carcel lamp, the, 256.
- Carr (W.) on cooking by gas, 269.
- Cast and wrought-iron gasholder tanks, 125, 129, 132, 141, 142.
- Castings of main pipes, 165.
- Cast-iron pipes, 166 to 169.
  - cost of laying, 176.
  - weight and cost of, per yard, 178 to 186.
  - weight of lead for jointing, 171.
- Cast-iron retorts, 52, 58, 59.
  - duration of, 59.
  - Fraser's ribbed, 58.
- Cathels' washer, 92.
- Caustic soda and sulphide of sodium, purification by, 104.
- Cement, for joining ends of clay retorts, 66.
  - for jointing retort mouthpieces, 66.
  - for steam joints, 92.
  - for stopping leaks in boilers, 91.
  - glue, to resist moisture, 237.
  - iron or rust, 66, 171.
  - mastic, for buildings, 316.
  - mortar, Portland, 128.
  - or luting for retort lids, 66.
  - Portland, 128.
  - Roman, 167.
- Centigrade thermometer compared with Fahrenheit and Reaumur, 86, 87.
- Centre and other change valves, 109.
- Chains, safe load on, 323.
  - weight of, 323.
- Chandeliers and brackets, height of, 228.
- Change valves, 109.
- Changer, Cowan's automatic pressure, 164.
- Charging shovels, 67.
- Chemical and other memoranda, 294.
  - common names of certain chemical substances, 296.
  - elementary substances, 295.
  - expansion of liquids from 32° to 212° Fahr., 298.
  - luting, for experiments in chemistry, 298.
  - specific gravity, weight aud solubility in water, of various gases, 297.
  - specific heat of solids and liquids, 299.

Chemical (*continued*).
  substances, simple and compound, 295.
  water, memoranda relating to, 298.
Cherry coal, 1.
Chief kinds of coal, 1.
Chimney stalks for retort houses, 57.
  rule for size of, 57.
Chlorine and durability test, 43.
Choking of ascension pipes, 69.
Circumferences, &c., table of, 366.
Cistern for tar and liquor, elevated, 98.
Classification of limestones, 104.
Clay, fire, 316.
  constituents of, 317.
Clay puddle, 129.
Clay retorts, 52 to 59.
  temperature of carbonization with, 58.
  thickness of, 55.
Clay and iron retort settings, combined, 59.
Clegg's continuous stoking machinery, 67.
Cleland's slow speed condenser, 80.
  and Körting's steam jet exhauster, 89.
Coal, 1 to 49.
  analysis of, 1 to 49.
  analysis of the ash of a good Newcastle, 4.
  annual consumption of, for gas purposes in United Kingdom, 47.
  anthracite or glance, 1, 46.
  ash in, 4 to 42.
  bituminous, 1, 46, 47.
  "brasses" in, 48.
  brown or lignite, 1.
  carbon in, 3.
  chief ingredients of which it is composed, 3.
  chief kinds of, 1.
  coke, production of, from 6 to 42.
  Cumberland, 21.
  Derbyshire, 3, 21.
  deterioration of, by exposure, 47.
  gases occluded in, 48.
  glance or anthracite, 1, 46.
  Gloucestershire, 3, 31.
  hydrogen in, 3.
  in hot climates, deterioration of, 48.

oal (*continued*).
  iron pyrites in, 5, 48.
  Lancashire, 3, 21, 44.
  lignite or brown, 1.
  measures, area of, in the United Kingdom, 5.
  mixture of, with other substances, 23, 24, 25.
  nitrogen in, 3.
  Newcastle, 3, 4, 20, 44.
  nuts, slack and dross, 43.
  oxygen in, 3.
  parrot or cannel, 1, 46.
  production of coke from, 3 to 44.
  products, 280 to 293.
  Scotch, 4.
  sheds, 47.
  Somersetshire and other, 4, 32.
  Staffordshire, 21.
  storage, 46, 47.
  sulphur in, 3 to 42.
  value of, in pounds of sperm, 45.
  volatile matter in, 6.
  Welsh, 4, 21, 30.
  Wigan, 44.
  yield of sulphate of ammonia per ton, 274.
  Yorkshire, 21.
oating and painting of gasholders, 146.
  of main pipes, 173.
oke and breeze, 270.
  ash in, 6 to 42.
  breaking hammer, 270.
  breaking machinery, 270, 271.
  production of, from coal, 6 to 42.
  sulphur in, 3 to 42.
oloured fires for illumination, 242.
  blue or Bengal, 243.
  crimson, 243.
  green, 243.
  lilac, 242.
  mixing the ingredients for, 244.
  purple, 242.
  red, 243.
  white Indian, 244.
  yellow, 243.

Coloured glass, loss of light through, 231.
Colours of high temperatures, 63.
  used in mechanical and architectural drawing, 333.
Columns, height of lamp, 206.
Combined settings of clay and iron retorts, 59.
  atmospherical and water condenser, 81.
Commercial and structural value, 332.
Common names of certain chemical substances, 296.
Comparison of Fahrenheit's, Reaumur's, and the Centigrade thermometer, 86, 87.
Compensating meters, 210.
  Hunt's, 211.
  Sanders and Donovan's, 210.
  Urquhart's "Reliance," 211.
  Warner and Cowan's, 210.
Composite tanks, 139.
Composition pipes, 233.
Composition of gas lime, and its use in agriculture, 278.
Concrete and mortar, 127, 128, 129, 315.
Concrete tanks, 127, 140.
Condensation, 76.
  expansion of air and permanent gases by heat, 78.
  extent of,
  loss of illuminating property in coal gas on exposure to the temperature of freezing point, 77.
  mean temperature of every tenth day in the year, 78.
  rapid or sudden as well as excessive, 77.
  relative effects of water and air as cooling agents, 78.
  rules for calculating the area required for atmospherical condensation, 82.
  temperature as affecting registration, 77.
Condensers, 79.
  Aitken and Young's analyzer, 84.
  annular atmospherical, 79.
  area required for, rules for calculating, 82.
  battery or tubular, 82.
  bye-pass mains and valves for, 97.
  carburetting, 84.
  Cleland's slow-speed, 80.
  combined atmospherical and water, 81.
  condensing surface at several London gas works (1871), 85.
  dry scrubbers as condensers, 83.
  Graham's horizontal, 81.

- densers (*continued*).
  - horizontal atmospherical, 80.
  - Kirkham and Wright's annular, 80.
  - St. John and Rockwell apparatus, 84.
  - tubular or battery, 82.
  - underground, 83.
  - vertical atmospherical, 79.
  - Warner's annular, 80.
  - water channel, 84.
- densible hydrocarbons, 71.
- ducting heat, relative power of metals for, 322.
- necting pipes for purifiers, 109.
- sumers' gas meters, 210.
  - apparatus required for testing, 211, 212.
  - compensating, 210.
  - dilatation of gas in contact with water, 226.
  - dry meter, description of the, 210.
  - effect of over-driving the meter wheel, 210.
  - Hunt's meter, 211.
  - inspection of, 211.
  - percentage tables for testing, 213.
  - protection of meters from frost, 211.
  - provisions of "Sales of Gas Act, 1859," as to stamping, 210.
  - sizes of meters desirable to be used, 211, 227.
  - testing, 211, 213.
  - Urquhart's "Reliance" meter, 211.
  - Warner and Cowan's meter, 210.
  - wet meter, description of the, 210.
- nsumption and pressure, 165.
- nsumption of coal for gas purposes in the United Kingdom, 47.
- nsumption of gas by one burner per month and for 12 months, 208.
- nsumption of gas per mile of main, 301.
- nsumption of gas per head of population, 301.
- ntraction of cast-iron pipes in cooling, 169.
- oking, use of gas for, 266.
- pper bronze powders, 235.
- rrections for temperature, pressure and moisture, 120, 246, 247, 250, 263.
  - in consumption of gas and standard candle, 247.
- st of gas per hour when burnt at certain rates, 307.
- ost of gas works, 300.
- ounterbalancing of gasholders, 144.

Cowan's automatic pressure changer, 164.
    governor, 163.
    ventilating globe lights, 229.
Crimson coloured fire, 243.
Crosley's pressure and exhaust registers, 123.
Cube roots of numbers, 339 to 364.
Cubes of numbers, 339 to 364.
Cubic foot measure, Referees', 252.
Cusiter's experiments on the absorption of the light-giving constit
    of coal gas, 72.

D retorts, 53, 54.
Damp or wet coals, result of using, 5, 48.
Damper to control draught, 56.
Day and night, rule to find the length of, 207.
Decimal system of weights and measures, 374.
Deposition of carbon in retorts, 62.
Derbyshire coals, 3, 21.
Deterioration of coal by exposure to weather, 47.
    in hot climates, 48.
Devices for public illuminations, 239.
    coloured fires, 242.
    illuminated borders, 242.
    prices of, 241.
Devonian rocks, 2.
Diameters, &c., table of, 366.
Differential or district governors, 165.
Dilatation of gas in contact with water, 226.
Dimensions of the principal materials in gasholders in actual worl
    149.
Dip in the hydraulic main, 71.
Dip pipes, 69.
Dip-well for sealing pipes, 98.
Disc for testing illuminating power, 244.
Discount for early payment of gas bills, 329.
District or differential governors, 165.
Distance apart of public lamps, 206.
Double retort benches, 49.
Douglas's instructions for preparing concrete, 127.
Draught and flues, 56.
Drawing papers, sizes of, 333.
Drip or syphon wells, 173, 174, 203.
Drory's main thermometer, 110.

ɔss or slack, 43.
y meter, description of the, 210.
y scrubbers as condensers, 83.
y or stand-pipe wells for gasholder tanks, 129.
long's experiments on the burning of hydrogen, carbon, and carbonic oxide, 56.
rability test, 43.
ration of retorts, 53, 59.

rths, natural slope of, 126.
  and rocks, weight of various, 126.
onomy of gas compared with other light giving materials, 304.
ge's method of scurfing retorts, 62.
ect of over-driving a meter wheel, 210.
  of small and bad pipes and fittings, 227.
ɔmentary substances, table of, 295.
ɔvated tar and liquor cistern, 98.
ɔvating apparatus for purifying material, 105.
gine and boiler, steam, 90.
  gas, 91, 266.
itome of mensuration, 334.
ans's analysis of coals and cannels, 25, 29.
aporation from water-slide pendants, to prevent, 228.
ils attending the use of small pipes, &c., 200.
amples of construction of gasholders, 149.
  of gasholder tanks, 132.
cavations for gasholder tanks, 125.
hausters, 88.
  advantages of using, 88.
  Anderson's, 89.
  Beale's, 89.
  bye-pass mains and valves for, 97.
  Cleland and Körting's steam jet, 89.
  governor for, 90.
  Jones's, 89.
  Laidlaw's, 89.
  Methven's, 89.
  Musgrave's, 89.
  Paterson's (R. O.) experiments with steam jet, 90.
  rotatory and reciprocating, 89.
cpansion joints for main pipes, 172.
  of air and permanent gases by heat, 78.
  of liquids in volume from 32° to 212° Fahr., 298.

Expansion of metals, 322.
Experimental governor, 245.
  meter, 244, 252.

Fahrenheit's thermometer compared with Reaumur's and the Centigrade, 86, 87.
Faija on Portland cement, 128.
Fiddes' analysis of coals and cannels, 26, 30.
  proposed standard light, 256.
Fireclay, 316.
  constituents of the chief English and foreign, 317.
  retorts, 52.
Fire or grate bars, 57.
Fires, coloured, for illuminations, 242.
Fittings, internal, 227.
  service, 199, 203.
Flange joints for main pipes, 169, 172.
Floor, retort house, 50.
  stage, 50.
Flues and draught, 52, 56.
Fluxes for soldering, 234.
Force and velocity of the wind, 324.
Fourth and fifth powers of numbers, 364.
Forms, 329.
  authority to pay dividends, 331.
  certificate showing that income tax has been deducted, 331.
  declaration for loss of sealed share certificates, 330.
  declaration of transmission of shares, from wife to husband, in consequence of marriage, 330.
  indemnity for loss of share certificates or dividend warrant, 330.
  of proxy, 331.
  renouncement of proposed new issue on the transfer of old shares, 329.
  renunciation of shares newly allotted, 329.
Foulis's hydraulic stoker, 67.
Frankland (Professor) on the volumes of various gases absorbed by 100 volumes of water, 97.
  on variations in illuminating power, 257.
Fraser's ribbed iron retorts, 58.
Freezing point, loss of illuminating property in coal gas on exposure to the temperature of, 77.
Freezing of water in gasholder tanks, 144.
  of water in governor tanks, 164.

- nch weights and measures, 374.
- st, protection of meters during, 211.
  - public lights during, 206.
- el for carbonizing, 59.
  - tar as, 59.
- rnaces, generator and regenerative, 60.
  - retort, 57.
- fe's (Dr.) chlorine and durability test, 43.

- lvanized pipes, 199, 205, 206.
- s, absorption of the light giving constituents of coal, 72.
  - and air, expansion of, by heat, 78.
  - dilatation of, in contact with water, 226.
  - loss of illuminating property in, on exposure to the temperature of freezing point, 77.
  - value of, per cubic foot in grains of sperm, 45.
- seous hydrocarbons, 71.
- ses occluded in coal, 48.
  - various, their specific gravity, weight and solubility in water, 297.
- s engine, 91, 266.
- sholders, 144 to 162.
  - capacity, 145, 147.
  - counterbalanced, 144.
  - dimensions of the principal materials in, 149.
  - painting of, 146.
  - precautions to be observed in the working of, 146.
  - pressure of, to ascertain, 149.
  - recipe for coating, 146.
  - rise in the crown of, 145.
  - single-lift, 144, 149 to 154.
  - telescopic, 144, 154 to 162.
  - trussed and untrussed roofs, 145.
  - weight of, to ascertain, 148.
- sholder tanks, 125 to 144.
  - annular, 125, 142.
  - Arson (M.) on masonry walls of, 130.
  - asphalte or tar concrete and mortar for, 128, 129.
  - brick and puddle, 125, 133.
  - cast and wrought-iron, 125, 129, 132, 141, 142.
  - cement mortar for, 128.
  - composite, 139.
  - concrete, 127, 140.

Gasholder tanks (*continued*).
  Douglas's instructions for preparing concrete, 127.
  dry wells, 129.
  examples of construction of, 132 to 144.
  excavations for, 125.
  Faija on Portland cement, 128.
  hydraulic lime mortar for, 128.
  leakage of water from iron, 129.
  materials of which tanks are constructed, 126.
  natural slope of earths, 126.
  Pole (Dr.) on masonry walls of, 130.
  puddle, clay, for, 129.
  stone, 126, 140.
  thickness of walls of, 129.
  weight of various earths and rocks, 126.
  wrought-iron, 142.
Gas lime, 278.
  its composition, and use in agriculture, 278.
  results obtained by applying certain manures to land, 279.
Gas Managers, golden rules for, 308.
Gas meters, consumers', 210.
  apparatus required for testing, 211, 212.
  compensating, 210.
  dilatation of gas in contact with water, 226.
  dry, description of the, 210.
  effect of overdriving the measuring wheel of, 210.
  Hunt's compensating, 211.
  inspection of, 211.
  percentage tables for use in testing, 213.
  protection of, from frost, 211.
  provisions of Sales of Gas Act, 1859, as to stamping, 210.
  Sander's and Donovan's, 210.
  sizes of, desirable to be used, 211, 227.
  testing, 211.
  to ascertain the number of lights a meter will supply, 227.
  Urquhart's "Reliance" meter, 211.
  Warner and Cowan's, 210.
  wet, description of the, 210.
Gas works, buildings and apparatus of a, 300.
  capital of, 300.
  conduct of a, 300.
  cost of, 300.
  design of, 300.

s works (*continued*).
    ornamentation in, 300.
    site for a, 300.
s-Works Clauses Act, 1871, on testing for illuminating power, 245.
    on testing for purity, 112.
uges, pressure, 123.
    coloured water for, 123.
    differential, 123.
    King's, 123, 245.
    Referees', 254.
    to clean the glass tubes of, 123.
nerator and regenerative furnaces, 57, 60.
    Siemens's, 60.
    Webber on, 61.
sner on the distillation of Newcastle cannel for gas and oil, 43.
ance or anthracite coal, 1, 46.
ass, loss of light through, 231.
    for public lamps, weight and thickness of, 207.
be and sun lights, ventilating, 229.
bes and shades, loss of light through, 231.
ue cement to resist moisture, 237.
ddard on scurfing retorts, 62.
ld bronze powders, or aurum mosaicum, 235.
lden rules for gas managers, 308.
oucestershire coals, 3, 31.
vernor, district or differential, 165.
    pressure and consumption, 165.
vernor, exhauster, 90.
vernor, experimental, 245.
vernor or regulator for internal fittings, 230.
vernor, station, 162.
    advantages of the, 162.
    Braddock's, 163.
    bye-pass mains and valves for, 97.
    construction of the, 162.
    Cowan's, 163.
    Cowan's automatic pressure changer for, 164.
    freezing of water in tanks of, 164.
    Hartley's improvements in, 163.
    Hunt's, 164.
    Peebles's, 163.
    steam stove for governor-house, 164.

Governor (*continued*).
valves as governors of pressure, 162.
variations of pressure according to level, 164.
Graduated bar of photometer, 245.
Graham's horizontal condenser, 81.
Gravity, specific, and weight of various substances, 325.
to convert into Twaddel, 274.
Green bronze, 234.
Green coloured fire, 243.
Grice's self-sealing retort lids, 67.

H or bridge pipes, 69.
Hammer for breaking coke, 270.
Handy multiplier for wrought-iron, 318.
rule for ascertaining the weight of gas in a holder, 266.
rule for finding the content of a pipe in gallons and cubic feet, 198.
Harcourt's proposed pentane gas standard light, 256.
sulphur test, 112.
Hartley's experiments on the loss of light through sheet glass, globes, &c., 232.
improvements in station governors, 163.
Hawkins's method of revivifying oxide of iron *in situ*, 101.
Heat-conducting power of metals, 322.
expansion of air and permanent gases by, 78.
specific, of solids and liquids, 299.
Heating, use of gas for, 266.
Heats of retorts, 58, 59.
Height of brackets and chandeliers, 228.
of retort house chimneys, 56.
Hemp ropes, to find the weight of, 324.
Henry's (Dr.) table of quality of gas at different periods of distillation, 64.
Hills's experiments on purification by means of ammonia, 104.
Hislop's practical analysis of Scottish cannel coals, 33.
process for calcining spent lime, 101.
Holders, gas, 144 to 162.
capacity, 145, 147.
counterbalanced, 144.
dimensions of the principal materials in, 149.
painting of, 146.
precautions to be observed in the working of, 148.
pressure of, to ascertain, 149.
recipe for coating, 146.
rise in the crown of, 145.

Holders, gas (*continued*).
    single lift, 144, 149 to 154.
    telescopic, 144, 154 to 162.
    trussed and untrussed roofs, 145.
    weight of, to ascertain, 148.
Holman's eccentric fastener for retort-lids, 66.
Horizontal burners, objectionable, 228.
    condensers, 80.
Hours, number of, during which gas is usually burnt, 209.
Hughes's classification of limestones, 104.
Hulett's service cleanser, 200.
Hunt's compensating meter, 211.
    station governor, 164.
Hydraulic centre valve, 108.
Hydraulic lime mortar for gasholder tanks, 128.
Hydraulic lute for purifier covers, 108.
Hydraulic main, 70.
    dip in the, 71.
    size of the, 70.
    the "Livesey," 70.
Hydrocarbons absorbed by india-rubber tubing, 230.
    condensible, 71.
    gaseous, 71.
    volatile, 71.
Hydrogen in coal, 3.
Hydrometer, Beaumé's, 276.
    Twaddel's, 274.

Illuminating power, 244.
    and value of coals and gas in pounds of sperm, 45.
    apparatus for testing the, 244.
    Bunsen photometer, 244.
    calculations for corrections in the consumption of gas and the standard candle, 247.
    candle balance and weights, 245.
    corrections for temperature and pressure, 246, 250.
    disc for testing, 244.
    experimental governor, 245.
    experimental meter, 244, 252.
    from different coals and cannels, 19 to 42.
    graduated bar of photometer, 245.
    impurities and, 112.
    instructions of Referees on testing for, 246.

Illuminating power (*continued*).
    Kirkham and Sugg's retrograde scale for jet photometer, 259.
    King's pressure gauge, 245.
    loss of, on exposure to freezing point, 77.
    loss of, through globes, shades, and flat glass, 231.
    Letheby-Bunsen photometer, 244.
    Lowe's jet photometer, 258.
    mode of testing for, 245.
    pressure and, 230.
    Referees' cubic foot measure, 252.
    registration of observations, 247.
    standard burners for testing, 248.
    standard sperm candle, 244.
    statement of testings for, 249.
    statutory regulations for testing, 245.
    Sugg's illuminating power meter, 260.
    Sugg's photometrical table, 255.
    thermometer and barometer, 245.
    Thorp and Tasker's jet photometer, 261.
    variations in the, 257.
    various proposed standards of light, 256.
Illuminating power meter, 260.
Illumination devices, 239.
    Brunswick stars, 239.
    coloured fires, 242.
    crowns, garlands, plumes, scrolls, &c., 239.
    illuminated borders, 242.
    letters, single and double lined, 239.
    mode of supply and charge for gas, 238.
    service or supply pipes, 239.
Illuminations, public, 238.
Impurities and illuminating power, 112.
    in coal gas, 99.
    tests for the detection of, 110.
India-rubber tubing, absorptions of the hydrocarbons by, 230.
    varnish for, 230.
Ingredients, chief, of which coal is composed, 3.
Inspection of consumers' meters, 211.
Instructions for preparing concrete, 127.
    of the London Gas Referees, 116, 246.
Internal fittings, 227.
    absorption of the hydrocarbons by india-rubber tubing, 230.
    Bray's ventilating globe lights, 229.

nternal fittings (*continued*).
  burners in the horizontal position, objectionable, 228.
  Cowan's ventilating globe lights, 229.
  effect of small and bad pipes and fittings, 227.
  handy rule for estimating the number of burners for lighting large buildings, 230.
  height of chandeliers and brackets, 228.
  lighting of ordinary rooms, 228.
  loss of light through shades, globes, and flat glass, 231.
  Peebles's "Needle" governor burner, 230.
  pressure and illuminating power, 230.
  regulations as to, 227.
  regulator or governor for, 230.
  salad oil in water slide pendants, to prevent evaporation, 228.
  sizes and lengths of pipes for number of lights supplied, 228.
  sizes of meters for number of lights supplied, 227.
  Strode's ventilating sunlight, 229.
  Sugg's ventilating globe lights, 229.
  varnish to prevent the escape of gas through india-rubber tubing, 230.
  ventilating globe and sun lights, 229.
  ventilation of rooms, 229.
  Wright's "Acme" regulating burner, 230.
ron and brass, mixture for tinning, 234.
  breaking weight of ropes of iron and steel wire, 324.
  contraction of cast-iron in cooling, 169.
  corrugated-iron roofing, 321.
  flat bar, 318.
  handy multiplier, for wrought, 318.
  hoop-iron, 321.
  lineal expansion of metals, 322.
  nuts and bolt heads, 322.
  round bar, 318.
  safe load on chains, 323.
  sheet-iron and steel, 319.
  square bar, 319.
  steel, 320.
  taper angle-iron of equal sides, 321.
  taper T-iron, 321.
  weight of a sphere 1 inch in diameter, 321.
  weight of a superficial foot of iron, 320.
  weight of chains, 323.
  Whitworth's screws with angular threads, 322.

Iron gasholder tanks, 125, 129, 132, 141, 142.
    leakages of water from, 129.
Iron, lead, and composition pipes for internal supply, 228.
Iron, oxide of, purification by means of, 100, 101, 102, 108.
Iron pyrites in coal, 48.
Iron retorts, 52, 58, 59.
    clay and, combined settings of, 59
    dimensions of, 58.
    duration of, 59.
    Fraser's ribbed, 58.
    scurfing of, 59.
    temperature suitable for, 59.
    weight of, 58.

Jet photometer, 258.
    Lowe's, 258.
    Thorp and Tasker's, 261.
Jet, steam, exhauster, 89.
Joining the ends of clay retorts, cement for, 66
Jointing retort mouthpieces, 66.
Jointing space in main pipes, 166.
Joints of main pipes, 166 to 173.
    service-pipes, 199, 201.
Jones's exhauster, 89.

Keates's moderator lamp as a proposed standard of light, 256.
King's pressure gauge, 123, 245.
King's (W.) table showing loss of light through glass shades or globes, 2
Kirkham and Sugg's improved Lowe's jet photometer, 258.
    retrograde scale for jet photometer, 259.
Kirkham and Wright's annular condenser, 80.
Kirkham, Hulett, and Chandler's washer-scrubber, 97.
Körting and Cleland's steam jet exhauster, 89.

Lacquer and varnish, 236.
    deep gold, 236.
    fine pale, 236.
    gold, 236.
    green, 237.
    iron, 237.
    red, 236.
    simple pale, 236.
    yellow, 237.

cquering brass work, 237.
idlaw's exhauster, 89.
ming' experiments in purification by means of ammonia, 104.
mp, the carcel, 256.
  Keates's moderator, 256.
mp columns, 206.
  distance apart of, 206.
  height of, 206.
  size of pipe in, 206.
mps, street, 206.
  average meter system for, 207.
  Bray's, 206.
  regulators for, 207.
  Siemens's, 206.
  Sugg's, 205.
  supply of gas to, 207.
  thickness of glass for, 207.
ncashire coals, 8, 21.
w terms, 332.
ycock and Clapham's washer-scrubber, 97
yers of purifying material in purifiers, 108.
ad and composition pipes, 228, 233.
  lengths and weight per yard, 233.
ad paper, to prepare, 111.
ad, molten, 171.
  red and white, 170.
  weight of, for jointing mains, 171.
ad rings for jointing, 172.
ad service pipes, 199.
akage from boilers, cement for stopping, 91.
  main pipes, 165.
  of water from iron gasholder tanks, 129.
  service pipes and fittings, 199.
ases, terms for, 332.
ngth of day and night, rule to find the, 207.
heby (Dr.), composition of London gas (1866), 304.
  method of determining the specific gravity of gas, 262.
  on proportion of products from coal tar, 272.
  on purification of gas, 103.
  on values of different illuminating agents, 304.
heby-Bunsen photometer, 244.
s and lid fasteners for retorts, 65.
  retort, luting for, 66.

Lids (*continued*).
    retort, Morton's and other self-sealing, 66.
    purifier, apparatus for raising, 109.
Lifting apparatus for purifier covers, 109.
Light, loss of, through globes and flat glass sheets, 231.
    through mixing air with gas. 259.
Light, standards of, 256.
Lighting of large buildings, 230.
    of ordinary rooms, 228.
    public, 206.
Lights, coloured, 242.
    number of, supplied by different diameters and lengths of pipe, 228.
    number of, supplied by different sized meters, 227.
    ventilating globe and sun, 229.
Lignite or brown coal, 1.
Lilac coloured fire, 242.
Lime, Forstall's instructions for preparing, for the purifiers, 100.
    gas, or spent, 278.
    Hislop's process for calcining spent, 101.
    hydraulic, 128.
    preparation of, for purifying, 100.
    purification by, 100.
    quantity of, required to purify the gas obtained from cannel and coal, 101.
    quick, 100, 105.
Lime water, to prepare, 111.
    weight and measurement of, 105.
Limestones, classification of, 104.
    their composition and specific gravity, 105.
Liquids and solids, specific heat of, 299.
Liquids, expansion of, 298.
Liquor, ammoniacal, 273.
Litmus paper, to prepare, 111.
Livesey's analysis of coals, 26.
    experiments in purification by ammonia, 104.
    hydraulic main, 70.
    scrubber, 94.
    washer, 93.
London argand No. 1. Sugg's, 248.
London gas, composition of (1866), 304.
London Gas Referees' cubic foot measure, 252.
    instructions for testing, 116, 246.

ondon Gas Referees' (*continued*).
  pressure gauge, 254.
  sulphur test, 112.
ondon gas works, condensing surface at several, 85.
oss of illuminating property in coal gas on exposure to freezing point, 77.
  of light by mixing air with gas, 257.
  through globes and flat sheets of glass, 231.
ute or seal, depth of, for purifier covers, 108.
uting for retort lids, 66.
  of joints in chemical experiments, 298.

achinery used for charging and discharging retorts, 67.
  used for coke breaking, 270, 271.
ain, hydraulic, dip in the, 71.
ainlaying, 173.
  appliances used in, 174.
  average cost per yard of, 176.
ain pipes, 165.
  appliances used in laying, 174.
  average cost per yard of laying, 176.
  ball and socket joints for, 172.
  casting of, 165.
  coating of, 173.
  discharge of gas per hour through, 187.
  dimensions of sockets of, 168.
  drip or syphon wells for, 173, 174.
  expansion joints for, 172.
  flanged joints of, 169, 172.
  formula for calculating the weight of, 165.
  iron or rust cements for joints of, 171.
  jointing space in, 166.
  joints of, 166 to 173.
  laying of, 170, 173, 176.
  leakage from, 165.
  metal of, 165.
  open joints for, 166.
  overweight in, 165.
  recess for lead in front of turned joint, 167.
  red and white lead for joints of, 170, 173.
  should be drilled, not cut, for insertion of service pipes, 199.
  testing of, 165.
  turned and bored joints, 167, 168, 169.

Main pipes (*continued*).
    Upward's drilling apparatus for, 199.
    vulcanized india-rubber joints for, 170, 172.
    weight and cost per yard of, 178.
    weight of lead required for jointing, 171.
Mains, consumption of gas per mile of, 301.
    population per mile of, 301.
    rental per mile of, 301.
Main thermometer, Drory's, 110.
Malam's arrangement of purifiers, 106.
Mann's scrubber, 95.
Masonry tank walls, 130.
Mastic cement for buildings, 29.
Materials in gasholders, dimensions of, 149.
    of which gasholder tanks are constructed, 126.
Mean temperature of every tenth day in the year, 78.
Measures and weights, 370.
    decimal system of, 374.
Measure, Referees' cubic foot, 252.
Measuring wheel or drum of a meter, 121, 122, 210, 227.
Mechanical and architectural drawing, colours used in, 333.
Memoranda, chemical and other, 294.
    miscellaneous articles, 326.
    office, 327.
    relating to water, 298.
Mensuration, epitome of, 334.
    approximate multipliers, 336.
    arithmetical and algebraical signs, 335.
    circle, cylinder, and sphere, 334.
    diameters, circumferences, areas of circles, and sides of equal squares, 366.
    ellipses, cones, and frustums, 335.
    evolution, or the extraction of roots, 335.
    fourth and fifth powers of numbers, 364.
    involution, or the raising of powers, 336.
    numbers, squares, cubes, square roots, cube roots, and reciprocals, 338 to 364.
    square, rectangle, and cube, 334.
    triangles and polygons, 335.
Metals, expansion of, 322.
    heat conducting power of, 322.
Meter, average system, for public lighting, 207.
Meter, station, 121.

eters, consumers', 210.
  apparatus required for testing, 211, 212.
  compensating, 210.
  dry meter, description of the, 210.
  effect of overdriving a measuring wheel, 210.
  Hunt's compensating, 211.
  inspection of, 211.
  percentage tables used in testing, 213.
  protection of, from frost, 211.
  provisions of Sales of Gas Act, 1859, as to stamping, 210.
  Sanders and Donovan's, 210.
  size of meters desirable to be used, 211, 227.
  testing of, 211.
  Urquhart's "Reliance," 211.
  Warner and Cowan's, 210.
  wet meter, description of the, 210.
ethven's exhauster, 89.
  proposed standard of light, 256.
eyer and Playfair (Drs.) on the gases occluded in coal, 48.
illar's table of amount and specific gravity of gas at different periods of distillation, 63.
illboard for jointing flanges, 172.
iscellaneous articles, memoranda, 326.
ixing of air and gas, effect of, 257.
ixing of the ingredients for coloured fires, 244.
ixture for tinning brass and iron, 234.
ixtures of cannel and coal, 23.
  coal and other substances, 25.
  different coals, 24.
oderator lamp, Keates's, 256.
oisture, corrections for, 263, 264.
  glue cement to resist, 237.
oon's rising and setting, 207.
ortar and concrete, 128, 315.
  blue lias lime concrete, 127, 315.
  cement mortar, 128, 315.
  coarse mortar, 315.
  hydraulic lime mortar, 128, 315.
  kind of, employed for tanks, 128.
  mastic cement mortar for buildings, 316.
  Portland cement concrete, 127, 315.
  tar mortar and concrete, 128, 129.
orton's self-sealing retort lids, 66.

Motive power, use of gas for, 266.
Mountings of retort bench, 51, 58, 70.
    buckstaves, 51.
    coke slaking apparatus, 51.
    furnace ash pans, 58.
    hydraulic main, 70.
    lids and lid fasteners, 65, 66.
    retort mouthpieces, 64.
Mouthpieces, retort, 64.
Multiplier for wrought-iron, 318.
Multipliers for facilitating calculations, 318, 336.
Muriate of ammonia, 276, 288.
Musgrave's exhauster, 89.

Natural slope of earths, 126.
"Needle" governor burner, Peebles's, 230.
New red sandstone, 2.
Newcastle coals and cannels, 3, 4, 20, 44.
    distillation of, for gas and oil, 43.
    production per ton of, 44.
Night and day, to find the length of, 207.
Nitrogen in coal, 3.
Number of bricks in walls of different areas, 310 to 314.
Number of burners required to light large rooms, 230.
Number of hours during which gas is usually burnt, 209.
Numbers, squares, cubes, square roots, cube roots, and reciprocals, 338 to 364.
Nuts, cannel and coal, 43.

Objections to burners placed horizontally, 228.
Obstruction of light by globes, and flat glass, 231, 232.
Odling (Dr.) on purification, 102.
Office memoranda, 327.
    approximate multipliers, 336.
    arithmetical and algebraical signs, 335.
    authority to pay dividends, 331.
    books required in the keeping of a gas company's accounts, 327.
    certificates showing that income-tax has been deducted, 331.
    colours used in mechanical and architectural drawing, 333.
    declaration for loss of sealed share certificates, 330.
    declaration of transmission of shares, 330.
    discount for early payment of gas bills, 329.
    epitome of mensuration, 334.

fice memoranda (*continued*).
French weights and measures, 374.
indemnity for loss of share certificates or dividend warrant, 330.
law terms, 332.
renouncement of proposed new issue on the transfer of old shares, 329.
renunciation of shares newly allotted, 329.
sizes of drawing paper, 333.
structural and commercial value, 332.
terms for leases, 332.
weights and measures, 370.
ren's experiments in cooking by gas, 267.
l, salad, to prevent evaporation from water slide pendants, 228.
l red sandstone, 2.
namentation in Gas-Works, 300.
al retorts, 53.
ens and retorts of fire bricks and tiles, 54.
idation of pipes, 173, 200.
ide of iron, 101, 102.
average composition of native bog ore, 102.
precautions required in using fresh, 102.
purification by, 101, 102.
spent, 277.
ygen in coal, 3.

ldon's washer-scrubber, 96.
per disc for testing gas, 244.
per, sizes of drawing, 333.
per, lead, to prepare, 111.
litmus, to prepare, 111.
turmeric, to prepare, 111.
lby's self-sealing retort lids, 67.
rot or cannel coal, 1.
erson's (J.) analysis of coals and cannels, 34.
erson's (R. O.) experiments with the steam jet exhauster, 90.
terson's (R. H.) discoveries in purification, 101 to 104.
on keeping gas in contact with tar, 72.
rement, tar, 272.
let's table showing the relative effects of water and air as cooling agents, 78.
bles's "Needle" governor burner, 230.
station governor, 163.

Pendants, evaporation from water slide, 228.
Pentane gas, Harcourt's proposed standard light from, 256.
Permian series, 2.
Photometer, Bunsen's, 244.
    illuminating power meter, Sugg's, 260.
    Letheby-Bunsen, 244.
    Lowe's jet, 258.
    tables, 255.
    Thorp and Tasker's jet, 261.
Pipes and fittings, effect of small and bad, 227.
    sizes of, for internal supply, 228.
Pipes, ascension, choking of, 69.
    brass, plain, spiral and fluted, 233.
    bridge and dip, 69.
    connecting, for purifiers, 109.
    galvanized, 199, 205, 206.
    lead and composition, 233.
    main, 165 to 186.
    service, 199, 203, 204.
Playfair and Meyer (Drs.), on the gases occluded in coal, 48.
Pole (Dr.) on gasholder tank walls, 130.
Population per mile of main, 301.
Portland cement, 128.
    concrete, 127.
    mortar, 128.
Pouillet's table of colours corresponding to high temperatures, 63.
Powders, bronze, 235.
    size for, 235.
Precautions required in the working of gasholders, 146.
Pressure changer, Cowan's automatic, 164.
Pressure, consumption and, 165.
    illuminating power and, 230.
    variation of, according to level, 164.
Pressure gauges, 123.
    coloured water for, 123.
    differential, 123.
    King's, 123, 245.
    Referees', 254.
    to clean the glass tubes of, 123.
Pressure and exhaust registers, 123.
    Crosley's, 123.
    Wright's, 124.
Pressure and temperature, corrections for, 246, 250.

Pressure of gasholders, 149.
Pressures, square root of, from 1-10th to 4 inches, 197.
Price list of wrought-iron tubes and fittings, 204.
Price's coal and coke barrow, 67.
Producing power of various kinds of coals and cannels, 6 to 44.
Production of coke from coal, 6 to 44.
    of gas from coal, 6 to 44.
    per retort mouthpiece, 53.
Products, coal, 280 to 293.
    residual, 270 to 279.
Protection of meters from frost, 211.
Public illuminations, 238.
    coloured fires, 242.
    devices for, 239.
    illuminated borders, 242.
    mode of supply and price of gas, 238.
    price of devices, 241.
    service or supply pipes, 239.
Public lighting, 206.
    average meter system for, 207.
    consumption of gas by one burner throughout the year, 208.
    distance apart of public lamps, 206.
    during severe frost, 206.
    galvanized pipes for lamp columns, 206.
    height of lamp columns, 206.
    number of hours during which gas is usually burnt, 209.
    rule to find the length of day and night, 207.
    size of service pipes, 206.
    Sugg's, Bray's, and Siemens's lamps and burners, 206.
    weight and thickness of glass for public lamps, 207.
Puddle and brick gasholder tanks, 125, 133.
Puddle, clay, 129.
Purification, 99.
    bog ore, average composition of, 102.
    by ammonia in closed vessels, 104.
    by caustic ammonia, and carbonate of ammonia, 104.
    by caustic soda, and sulphide of sodium, 104.
    by lime (oxide of calcium), 100.
    by lime, sulphide of calcium, and oxide of iron, 102.
    by oxide of iron, 101.
    classification of the best known limestones, 104.
    extraction of bisulphide of carbon, 103.
    Forstall's instructions for preparing lime for purifiers, 100.

Purification (*continued*).
  Hawkins's method of revivification of oxide of iron *in situ*, 101.
  Hislop's process for calcining the spent lime, 101.
  impurities in coal gas, 99.
  Letheby (Dr.) on, 103.
  Odling (Dr.) on, 102.
  Patterson's (R. H.) researches in, 101 to 104.
  precautions required in using fresh oxide of iron, 102.
  removal of impurities by condensers, washers, and scrubbers 76 to 84.
  weight and measurement of lime, 105.
Purifiers, 105.
  apparatus for raising the lids or covers, 109.
  centre and other change valves, 109.
  construction and arrangement of, 105.
  depth and best form of, 107.
  depth of water lute, 108.
  Malam's arrangement of, 106.
  number of layers of purifying material, 108.
  rules for determining the size of, 107.
  sieves, trays or grids for lime and oxide of iron, 108.
  size of connecting pipes, 109.
  water lute for covers and hydraulic centre valve, 108.
Purifying house, 105.
  arrangement of, 105.
  ventilation of, 105.
Purple-coloured fire, 242.
Pyrites, iron, in coal, 5, 48.

Quantity of ash in coal, 3.
  brickwork in retort settings, 55.
  carbon, hydrogen, nitrogen, and oxygen in coal, 3.
  gas and coke obtained from coal and cannel, 6 to 44.
  gas per ton, and illuminating power, relation between, 46.
Quantity of sulphur in coal, 6 to 42.
  volatile matter in coal, 6 to 18.

Radiation from retort bench, 59.
Rake for discharging retorts, 67.
Rapid or sudden condensation, 77.
Reaumur's thermometer compared with Fahrenheit, and the Centigrade, 86, 87.
Recipe for tinning iron and brass, 234.

Reciprocals of numbers, 339 to 364.
Reciprocating and rotary exhausters, 89.
Red coloured fires, 243.
Referees' cubic foot measure, 252.
    instructions of the, 116, 246.
    pressure gauge, 254.
    sulphur test, 112.
Regenerative and generator furnaces, 60.
    Webbr on, 61.
Registers, pressure and exhaust, 123.
    Crosley's, 123.
    Wright's, 124.
Registration as affected by temperature, 77.
Regulating burner, Wright's "Acme," 230.
Regulations, as to internal fittings, 227.
    statutory, as to testing, 112, 210, 245.
Regulator or governor for internal fittings, 230.
Relation between quantity of gas per ton, and illuminating power, 46.
Relative value of different coals and cannels, 46.
    illuminating agents, 304.
"Reliance" meter, 211.
Rental per mile of mains, 301.
Residual products, 270.
    ammoniacal liquor, 273.
    average percentage products obtained from coal tar, 272.
    coke and breeze, 270.
    coke breaking hammer and machinery, 270, 271.
    coke produced from different coals, 4 to 44.
    coke, weight of a chaldron of, 271.
    coke, weight of, slaked and unslaked, 271.
    retort carbon, 270, 282.
    Sellers on coke breaking, 270.
    spent lime, 278.
    spent oxide of iron, 277.
    tar, 271.
    tar pavement, 272.
    total production of tar in the United Kingdom, 271.
    utilization of the tar, 271.
    yield of liquor and tar per ton of coal, 44, 47, 271.
    yield of sulphate of ammonia, 274.
Retorts, 52.
    burning of clay, 53.
    cast-iron, 52, 58, 59.

Retorts (*continued*).
    cements for joining clay retorts and mouthpieces, 66.
    clay retorts, 52.
    colours corresponding to various high temperatures, 63.
    combined settings of clay and iron, 59.
    cost of settings, 58.
    different forms of, 53.
    dimensions of retorts and settings, 54, 57.
    duration of clay and iron, 53, 59.
    Edge's method of scurfing, 62.
    firebrick retorts and ovens, 54.
    flues and draught for, 56.
    Fraser's ribbed iron, 58.
    fuel used for carbonizing coal in, 59.
    "gaiting" retorts, 56.
    heat of retorts for efficient carbonization, 58, 59.
    hints on the setting of, 55.
    "letting down" and "standing off" of, 58.
    materials of which retorts are made, 52.
    quantity of brickwork in retort settings, 55.
    regenerative and generator furnaces for, 60.
    scurfing retorts, 62.
    setting of retorts, 55, 59.
    single retorts, 52.
    tar as fuel for, 59.
    thickness of, 55, 58.
    "through" or double retorts, 54.
    usual number of retorts in an oven, 59.
Retort bench mountings, 58.
    ascension or stand pipes, 69.
    bridge and dip pipes, 69.
    buckstaves, 51, 52.
    cements for jointing retorts, mouthpieces, and lids, 66.
    coke slaking arrangement, 51, 52.
    furnace ash pans, 58.
    grate bars, 57.
    hydraulic main, 70.
    lids and lid fasteners, 65.
    Morton's and other self-sealing lids, 66.
    mouthpieces, 64.
    tie rods, 52.
Retort house, 49.
    chimney stalk for, 57.

Retort house (*continued*).
  clear space in front of benches, 50.
  dimensions of, 49.
  paving of floor of, 50.
  roof of, 49.
  rule for the size of chimneys, 57.
  stage floor, 50.
  ventilation of, 49.
Retort house tools and machinery, 67.
  ash-pan rake, and shovel, 67.
  auger, 67.
  charging scoop, 67.
  Clegg's arrangement for continuous carbonization, 67.
  discharging rake, 67.
  Foulis's hydraulic stoker, 67.
  machinery for charging and discharging retorts, 67.
  Price's coke and coal barrow, 67.
  pricker and fire tongs, 67.
  Ross's steam stoker, 67.
  shovels, 67.
  Warner's stoking machinery, 67.
  West's stoking machinery, 67.
Retort stack, 50.
  buckstaves and tie rods for, 52.
  buttress walls, 52.
  chimney stalk, 57.
  coke slaking arrangements on, 52.
  dimensions of, 51.
  main flue of, 52.
Ring or annular tanks, 125, 142.
Robinson's experiments in cooking by gas, 268.
Rocks and earths, weight of various, 126.
Roofs of retort houses, 49.
Rooms, lighting of large, 230.
  ordinary, 228.
Ropes, hemp and wire, 323.
  breaking weight of, 324.
  weight and strength of, 323, 324.
Roscoe (Dr.) on the proportion of products obtained from coal tar, 272.
Ross's steam stoker, 67.
Rotatory and reciprocating exhausters, 89.
Round ropes of hemp and wire, 323.
  retorts, 53.

Rule for estimating number of burners for lighting large buildings, 230.
  for roughly estimating amount of coal required to produce a given quantity of gas, 47.
  for size of retort house chimney-stalk, 57.
  specific gravity being known, to find weight and quantity of gas, 266.
  to ascertain the weight of gasholders, 148.
  to find the content of a pipe in gallons and cubic feet, 198.
  to find the length of day and night, 207.
  to find the pressure of gasholders, 149.
  to find the weight of gas in a holder, 266.
  to find the weight of hemp ropes, 324.
Rules for calculating the area required for atmospherical condensation 82.
  purifying area, 107, 108.
  to convert Fahrenheit into Reaumur and Centigrade, and conversely, 87.
  for gas managers, golden, 308.

St. John and Rockwell apparatus, 84.
Sal ammoniac, 278.
Salad oil in water slide pendants to prevent evaporation, 226.
Sales of Gas Act, 1859, provisions of, as to stamping meters, 210.
Salubrity, comparative, of different illuminating agents, 306.
Sand for mortar, 316.
Sanders and Donovan's compensating gas-meter, 210.
Saturation, testing ammoniacal liquor by, 275.
Scale for Lowe's jet photometer, Kirkham and Sugg's, 259.
Scoop for charging retorts, 67.
Scotch coal, 4.
Scottish cannel coals, analysis by Hislop, 33.
Scrubber, 93.
  Anderson's combined washer and, 96.
  Barker's mill for distributing water in, 95.
  bye-pass mains and valves for, 97.
  dry scrubbers as condensers, 83.
  filling material for the, 94.
  Kirkham, Hulett, and Chandler's "Standard" washer-scrubber, 97.
  Laycock and Clapham's "Eclipse" washer-scrubber, 97.
  Livesey's improvements in the, 94.
  Mann's, 95.

Scrubber (*continued*).
  number of volumes of various gases which 100 volumes of water can absorb, 97.
  open, 94.
  Paddon's washer-scrubber, 96.
  quantity of ammoniacal liquor obtained to outlet of, 278.
  rule for determining the size of tower, 96.
  tower, 98.
  water distributing apparatus for the, 95.
Scurfing retorts, 62.
Self-sealing retort lids, 66.
Sellers on coke breaking, 270.
Separator for tar and ammoniacal liquor, 98.
Service pipes and fittings, 199, 203.
  abrupt angles to be avoided in, 200.
  Barff-Bower process for preserving, 199.
  casing for, when laid in ground, 199.
  cast-iron, wrought-iron, and lead, 199.
  construction of, 199.
  diameter of, to supply lights at certain distances from mains, 202.
  Hulett's service-cleanser, 200.
  leakage from, 199.
  pitch of the Whitworth taps and dies for, 201.
  price list of, 205.
  sizes of, for supplying lights, 200.
  syphon or drip well for, 200, 203.
  tinned or galvanized, 199, 205, 206.
  to calculate the required size of, 201.
  uniformity in the screws or threads of, desirable, 201.
  Upward's drilling apparatus for, 199.
Settings, retort, 55.
Shades or globes, loss of light through, 231.
Sheds for the storage of coal and cannel, 47.
Shovels, retort-house, 67.
Siemens's regenerative furnaces, 60.
  street lamps and burners, 207.
Signs, arithmetical and algebraical, 335.
Silvering metals, mixture for, 235.
Single-lift gasholders, 144, 149.
Single retort benches, 49.
Site for a gas works, 300.
Size for bronze powder, 235.
Sizes of drawing paper, 333.

Sizes of mains, services, meters, and internal pipes desirable to be avoided, and used, 200, 211, 227.
Slack or dross, 43.
Slaked and unslaked coke, weight of, 271.
Slaking arrangements for coke, 52.
Slope of earths with horizontal line, natural, 126.
Slow speed condenser, Cleland's, 80.
Smith, Beacock, and Tannett's coke breaking machine, 270.
Smith (Graham) on mixing ashes with lime for mortar, 316.
Smithy ashes for mortar, 316.
Soldering, fluxes for, 234.
Solders, 234.
  brazing, or spelter, 234.
  fine, 234.
  for copper, 234.
  glazing, 234.
  pewterer's, 234.
  plumbing, 234.
  steel, 234.
Solids and liquids, specific heat of, 299.
Solubility in water of various gases, 297.
Solutions, to prepare test, 117.
Somersetshire coals, 4, 32.
Somerville's self-sealing retort lids, 67.
  and Thomas's coke-breaking machine, 271.
Specific gravity of coal, and to determine the, 3, 44.
  of gas, 261.
  a test of quality of gas, 261.
  Beaumé's hydrometer compared with, 276.
  corrections for temperature, pressure, and moisture in taking, 263.
  illuminating power and, compared, 257.
  Letheby's (Dr.) method of determining the, of gas, 262.
  of ammoniacal liquor, 275.
  of gases at end of each hour of distillation, 63.
  of limestones, 105.
  of various substances, 325.
  ordinary method of determining the, of gas, 262.
  specific gravity being known, to find the weight of a quantity of gas, 266.
  square roots of, from ·350 to ·700, 197.
  to convert Twaddel into, 274.
  weight and solubility in water of various gases, 297.
  Wright's method of determining the, of gas, 265.

Specific heat of solids and liquids, 299.
  Spence's metal, for jointing mains, &c., 171.
Spent lime, composition and use of, in agriculture, 278.
  Hislop's process for calcining, 101.
Spent oxide of iron, 227.
  quantity of free sulphur in, 277.
  salts of ammonia and insoluble cyanides in, 277.
  Stephenson's apparatus for estimating the sulphur in, 277.
Sperm candle, the standard, 244.
Sperm, value of coal and gas in pounds and grains of, 45.
Spiral and fluted brass tube, weight per foot, 238.
Splint coal, 1.
Spontaneous ignition of coal, 48.
Square roots of pressures from 1-10th to 4 inches, 197.
Square roots of the specific gravity of gas from ·350 to ·700, 197.
Squares, &c., of numbers, 339 to 364.
Stack, retort, 50.
Staffordshire coals, 21.
Stage floor retort houses, 50.
Stalks, rule for size of retort-house chimney, 57.
Standard burners, 245, 246, 248.
  sperm candle, the, 244.
  unit of heat, 56.
  washer-scrubber, 97.
Standards of light, proposed, 256.
  Fiddes's, 256.
  Harcourt's, 256.
  Keates's, 256.
  Methven's, 256.
Station governor, 162.
  advantages of the, 162.
  Braddock's, 163.
  bye-pass mains and valves for, 97.
  construction of the, 162.
  Cowan's, 163.
  Cowan's automatic pressure changer for, 164.
  freezing of water in tanks of, 164.
  Hartley's improvements in, 163.
  Hunt's, 164.
  Peebles's, 163.
  steam stove for governor-house, 164.
  valves as governors of pressure, 162.
  variations of pressure according to level, 164.

- Station meter, 121.
  - bye-pass mains and valves for, 97.
  - cylindrical and rectangular, 121.
  - mountings of, 122.
  - registering mechanism, 121.
  - rule to determine capacity of, 122.
  - tell-tale apparatus, 121.
- Station meter house, 120.
- Statutory regulations for testing, 112, 210, 245.
- Steam boiler and engine, 90.
  - cement for metallic joints, 92.
  - cement for stopping leaks in boilers, 91.
  - diameters of cylinders of steam-engines, 91.
  - horse power of steam boilers, 91.
- Steam jet exhauster, 89.
  - Paterson's (R. O.) experiments with the, 90.
- Steam stove for governor house, 164.
- Stephenson's apparatus for estimating the sulphur in spent oxide, 277.
- Stone gasholder tanks, 126, 140.
- Storage of coal and cannel, 46, 47, 48.
  - of gas, 145.
  - tar and ammoniacal liquor, 98.
- Storer and Pugh's lever handle for retort lids, 65.
- Storer (F. H.) on loss of light through flat sheets of glass, 231.
- Stove, steam, for governor house, 164.
- Strength of ammoniacal liquor, 274.
- Strode's ventilating sun lights, 229.
- Structural and commercial value, 332.
- Sudden or rapid condensation, 77.
- Sugg's illuminating power meter, 260.
  - London argand, No. 1, 248.
  - photometer table, 255.
  - street lamps and burners, 207.
  - ventilating lights, 229.
- Sulphate of ammonia, 273.
  - yield of, per ton of coal, 274.
- Sulphide of calcium, purification by, 102.
- Sulphide of sodium, and caustic soda, purification by, 104.
- Sulphur compounds in gas, test for the, 112, 118, 120.
- Sulphur in cannel, coal, and coke, 3 to 42.
  - spent oxide of iron, 277.
- Sulphur test, the Referees', 112.
- *Sulphuretted hydrogen*, test for, 111, 115, 116, 120, 292.

ns paid on the purchase of gas works by Local Authorities, 302
ı and globe lights, ventilating, 229.
ɔhon or drip wells, 173, 174, 200, 203.

ıks, gasholder, 125 to 144.
  annular, 125, 142.
  Arson (M.) on masonry walls of, 130.
  asphalt or tar concrete and mortar for, 128, 129.
  brick and puddle, 125, 133.
  cast and wrought-iron, 125, 129, 132, 141, 142.
  cement mortar for, 128.
  composite, 139.
  concrete, 127, 140.
  Douglas's instructions for preparing concrete, 127.
  dry wells, 129.
  examples of construction of, 132 to 144.
  excavations for, 125.
  Faija on Portland cement, 128.
  hydraulic lime mortar for, 128.
  leakage of water from iron, 129.
  materials of which tanks are constructed, 126.
  natural slope of earths, 126.
  Pole (Dr.) on masonry walls of, 130.
  puddle, clay, for, 129.
  stone, 126, 140.
  thickness of walls of, 129.
  weight of various earths and rocks, 126.
  wrought-iron, 142.
ınks or wells, content of, for each foot in depth, 99.
ır and liquor separator, 98.
ır as fuel, 59.
ır, coal, 271.
  pavement, 272.
  products from, 272.
  utilization of, 271.
  yield of, per ton of coal, 271.
ır pavement, 272.
  formation of, 272.
  preparation of materials for, 272.
ır well, 98.
  capacity of, for different sized works, 98.
  content of circular wells for each foot in depth, 99.
  dip-well for sealing pipes, 98.

Tar well (*continued*).
    elevated cast-iron cistern, 98.
    tar and liquor separator, 98.
Tassie's self-sealing retort lid, 67.
Technical quantities of miscellaneous articles, 326.
Telescopic gasholders, 144, 154.
    counterbalanced, 144.
    precautions necessary in the working of, 146.
Tell-tale apparatus for station meters, 121.
Temperature and pressure, corrections for, 246, 250.
    as affecting registration, 77.
    for carbonization, 53, 59.
    of clay retorts, 53.
    of gas in the bridge pipe, 76.
    of gas in the retorts, 73.
    of iron retorts, 59.
Temperatures, colours of high, 63.
Terms for leases, &c., 332.
Test, Referees' sulphur, 112.
Testing ammoniacal liquor, 274, 275.
Testing illuminating power, apparatus for, 244.
Testing, instructions of the Referees on, 116, 246.
Testing of main pipes, 165.
Testing of meters, 211, 213.
Testing, statutory provisions on, 112, 210, 245.
Tests for the detection of impurities in coal gas, 110.
    ammonia, 110, 117, 120.
    bisulphide of carbon, 113.
    carbonic acid, 111, 115.
    Gas-Works Clauses Act, 1871, on, 112.
    Harcourt's sulphur test, 112.
    sulphur, 112.
    sulphur compounds, 112, 118, 120.
    sulphuretted hydrogen, 111, 115, 116, 120.
    test solutions, to prepare, 117.
Thermometer and barometer, used in testing illuminating power, 245.
Thermometer, Drory's main, 110.
Thermometers, comparison of different, 86.
Thickness of the Birmingham wire gauge, 319.
Thickness of gasholder tank walls, 129.
Thomas and Somerville's coke breaking machine, 271.
Thompson's (Lewis) Analysis of coals and cannels, 5 to 18.
Thorp and Tasker's jet photometer, 261.

rough retorts, 54.
nned or galvanized-iron pipes, 199, 205, 206.
nning iron and brass, 234.
ols, retort house, 67.
wer scrubbers, 93.
ays or grids for purifiers, 108.
ias, Permian, and Carboniferous series in England and Wales, 2.
ussed and untrussed gasholder roofs, 145.
bes, brass, weight per foot, 233.
    wrought-iron fittings and, 203.
    price list of, 204.
ubular or battery condenser, 82.
urmeric paper, to prepare, 111.
urned and bored joints for main pipes, 167, 168.
waddel's hydrometer, 274.
    to convert into specific gravity, 274.

nderground condensers, 83.
niformity in the screws or threads of pipes and fittings, 201.
nit of heat, standard, 56.
ntrussed and trussed gasholder roofs, 145.
pward's drilling apparatus, 199.
rquhart's "Reliance" meter, 211.
se of gas for cooking, heating, and motive power, 266.
    advantages of the, 266.
    Carr (W.) on the, 269.
    Ohren's experiments in, 267.
    Robinson's experiments in, 268.
    Woodall's experiments in, 268.
seful information, relating to gas works, gas apparatus, gas manufacture, and supply, 300.
    buildings and apparatus of a gas works, 300.
    calorific power of various photogenic compounds, 306.
    capital of gas works, 301.
    comparative salubrity of illuminating materials, 306.
    comparison of gas with other light-giving materials, 304.
    conduct of gas works, 300.
    consumption of gas per mile of main, 301.
    consumption of gas per head of population, 301.
    cost of gas per hour at different prices and rates of consumption, 307.
    cost of gas works, 300.
    golden rules for gas managers, 308.

Useful information (*continued*).
    London gas, composition of, 304.
    ornamentation in gas works, 300.
    population per mile of main, 301.
    relative cost of the magnesium light, stearin candles, and gas, 306.
    relative cost of various illuminating agents, 305.
    relative proportions which ordinary light-giving materials bear to 1000 c. ft. of gas, 305.
    relative value of different illuminating agents, 304.
    relative value of illuminating agents, in respect of their heating and vitiating effects on the atmosphere, 305.
    rental per mile of main, 301.
    site for a gas-works, 300.
    sum paid for each £100 of share capital for gas undertakings by Local Authorities, 302.
    time in which the yearly consumption of gas is doubled at different rates of increase, 301.
Usual annual increase in gas consumption, 301.
Usual dimensions of bricks, 308.
Utilization of tar, 271.

Value of different coals and cannels, relative, 46.
    of coal per ton in pounds of sperm, 45.
    of gas per cubic foot in grains of sperm, 45.
Value, structural and commercial, 332.
Valves and bye-pass mains, 97.
Valves as governors of pressure, 162.
Valves, centre and other change, 109.
Variations in the illuminating power of gas, 257.
    of gas pressure according to level, 164.
Varnish and lacquer, 236.
    golden, 237.
    for india-rubber tubing, 230
    for iron-work, 237.
    for out-door wood work, 237.
Velocity and force of the wind, 324.
Ventilating globe and sun lights, 229.
Ventilation of purifying house, 105.
Vertical atmospherical condensers, 79.
Vitiating effects on the atmosphere of various illuminating agents, 305.
Voelcker on gas lime, and its use in agriculture, 278.
Volatile hydrocarbons, 71.

olatile matter in coal, 6.
    sulphur in, 6.
olume of aqueous vapour in gas in contact with water, 264.
    various gases which 100 volumes of water will absorb, 97.
ulcanized india-rubber joints for main pipes, 170, 172.

alls, thickness of gasholder tank, 129.
arner and Cowan's meter, 210.
arner's annular condenser, 80.
    stoking machinery, 67.
asher and scrubber, Anderson's combined, 96.
ashers, 92.
    advantages of using, 92.
    Anderson's, 92.
    Anderson's combined washer and scrubber, 96.
    bye-pass mains and valves for, 97.
    Cathels', 92.
    Kirkham, Hulett, and Chandler's washer-scrubber, 97.
    Laycock and Clapham's washer-scrubber, 97.
    Livesey's, 93.
    Paddon's washer-scrubber, 96.
ater, dilatation of gas in contact with, 226.
    leakages of, from iron gasholder tanks, 129.
    memoranda relating to, 298.
    proportion required for scrubbing purposes, 95.
    and air as cooling agents, compared, 78.
    and atmospherical condenser, combined, 81.
    channel condenser, 84.
    distributing apparatus in scrubbers, 95.
    in governor tanks, freezing of, 164.
    in lutes of telescopic holders, freezing of, 146.
    its power of absorbing ammonia, 94.
ebbber on regenerative and generator furnaces, 61.
eight and specific gravity of ammoniacal liquor, 275.
    brass tube per foot, 233.
    coal and cannel per cubic yard, 46.
    composition and lead pipes, 233.
    gasholders, 148.
    gas in a holder, rule to ascertain, 266.
    hemp ropes, rule to find the, 324.
    specific gravity and solubility in water, of various gases, 297.
    various earths and rocks, 126.
    various sections of iron and other metals, 318.

Weights and measures, 370.
  French decimal system, 374.
Well, dry, for gasholder tank, 129.
Welsh coals, 4, 21, 30.
West's stoking machinery, 67.
Wet meter, description of the, 210.
Wet or damp coal, result of using, 5, 48.
Wheel or measuring drum of a meter, 121, 122, 210.
White and red lead, 170.
White Indian fire, 244.
Whitworth's screws, 322.
  taps and dies for gas tubing, 201.
Wigan cannel and coal, production per ton of, 44.
Williams (Greville) on proportions of products from coal tar, 272.
Wills's method of testing ammoniacal liquor, 275.
Wilson on the results obtained by applying certain manures to land, 2
Wind, velocity and force of the, 324.
Wood casing for service pipes, 199.
Wood's (A. H.) table showing light obstructed by globes or moons, 23
Woodall's (H.) experiments in cooking by gas, 268.
Wright's "Acme" regulating burner, 230.
Wright's method of determining the specific gravity of gas, 265.
  pressure register, 124.
Wright and Kirkham's annular condenser, 80.
Wrought-iron gasholder tanks, 125, 129, 132, 142.
Wrought-iron, multiplier for, 318.
Wrought-iron tubes and fittings, 199 to 205

Yellow coloured fire, 243.
Yield of gas and coke of various coals and cannels, 3 to 44.
Yield of sulphate of ammonia per ton of coal, 274.
  tar per ton of coal, 44, 47, 271.
Yorkshire coals, 21.
Young's experiments on the condensation of the hydrocarbons, 72.
Young and Aitken's analyzer, 84.

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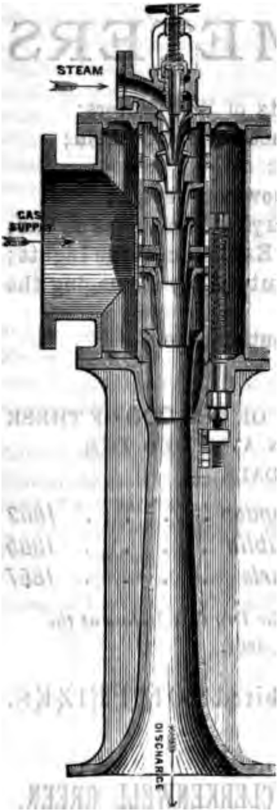

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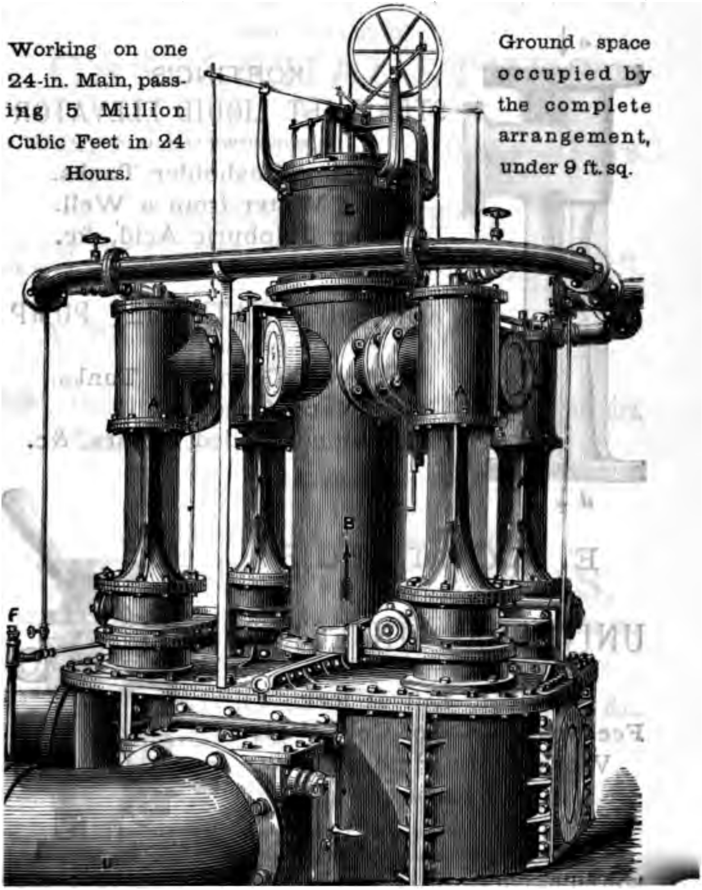

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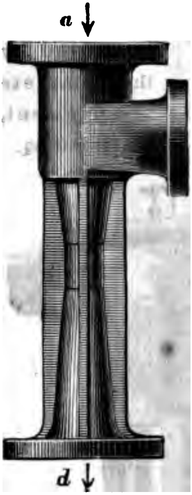

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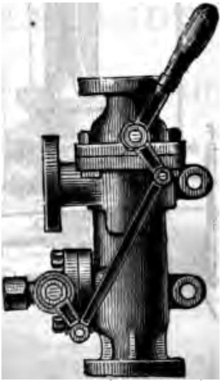

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THE ONLY KNOWN MEANS OF OBTAINING

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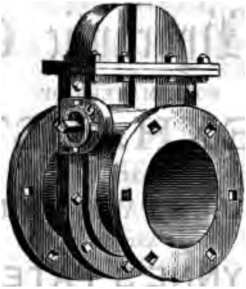

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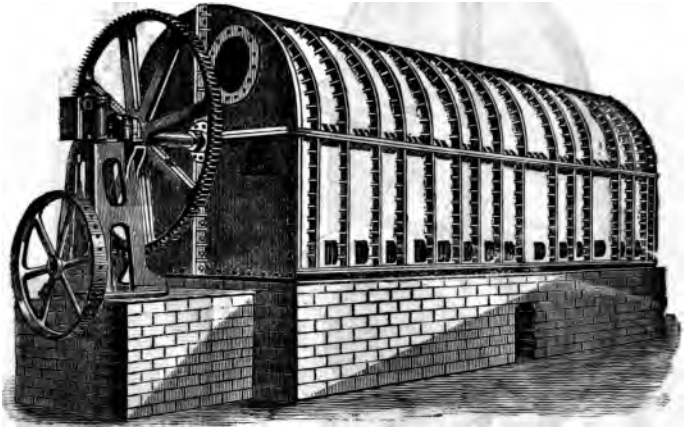

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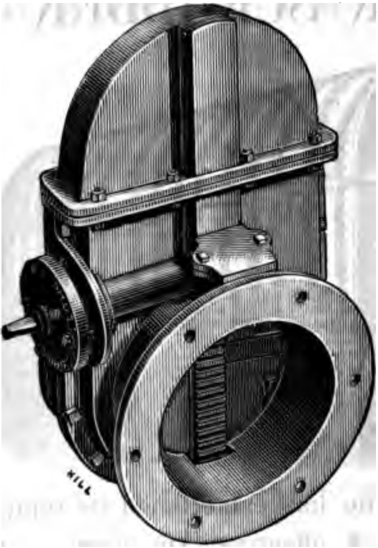

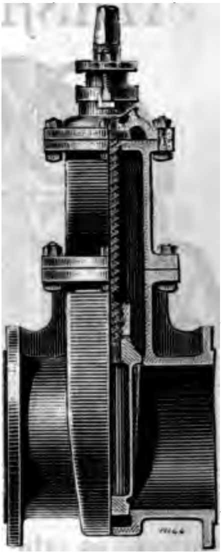

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FOR PURIFIERS,

Whereby all Four, or any smaller number of Purifiers, may be worked at once, or any one shut off for cleaning; thus utilizing all the Plant.

All Gas-Valves tested with Air to 30 lbs. on the square inch.

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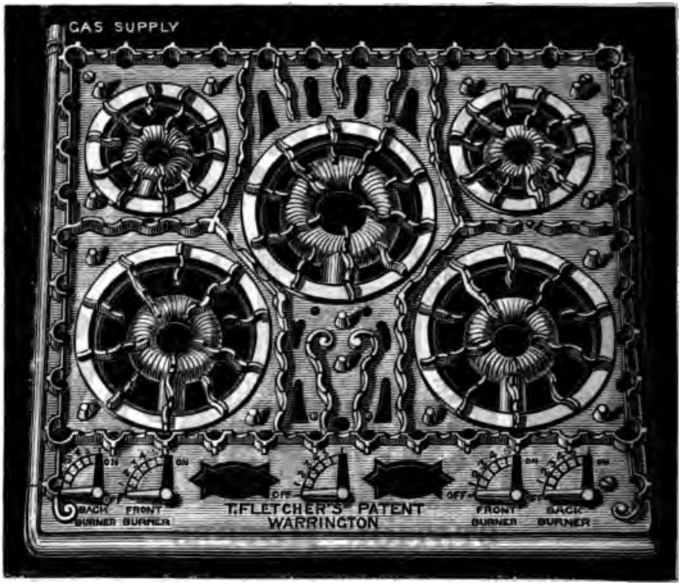
ALL SIZES AND SHAPES FOR ALL THE REGULAR PATTERNS OF OPEN RANGE, LEAMINGTON, AMERICAN, OR SCOTCH STOVES.



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Can be supplied also, with a simple, cheap, and efficient Gas arrangement, which can be fixed or removed in one minute, without alteration of landlord's fixtures, and used either alone or as an assistance to a coal fire.

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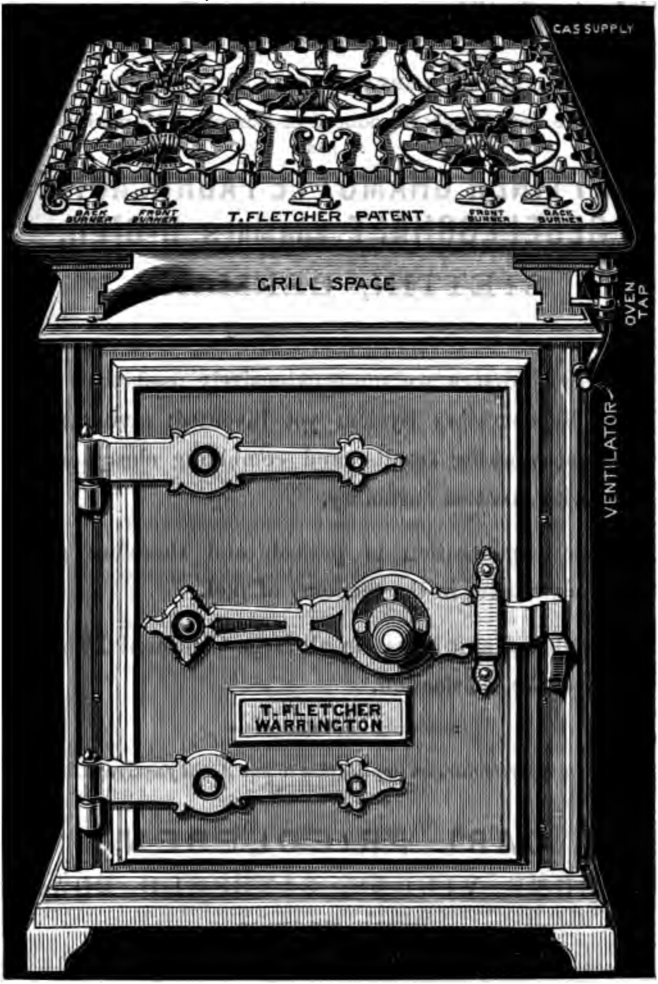

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PRACTICAL LEAD BURNERS SENT OUT TO REPAIRS.

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ERECTED ON SCIENTIFIC PRINCIPLES.

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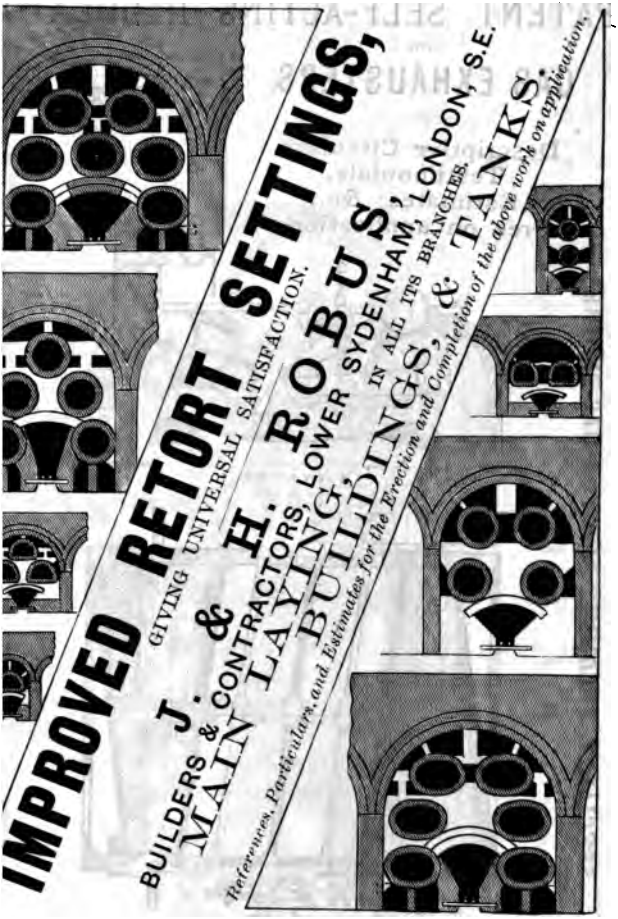

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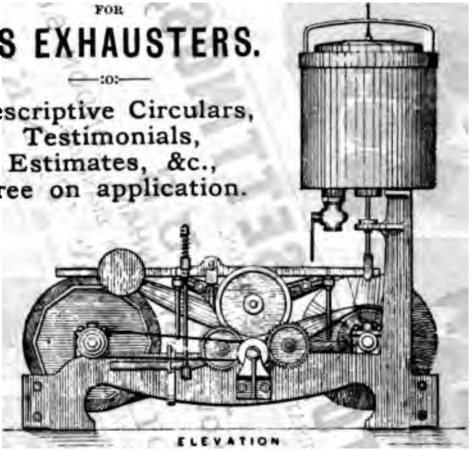

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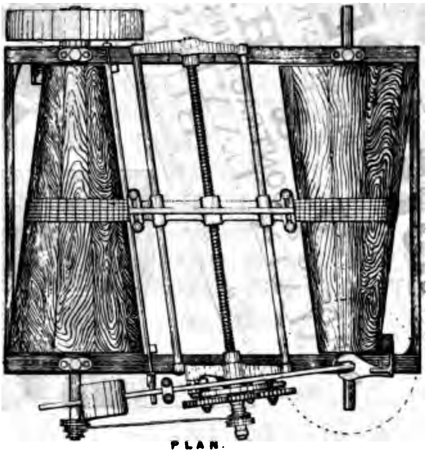

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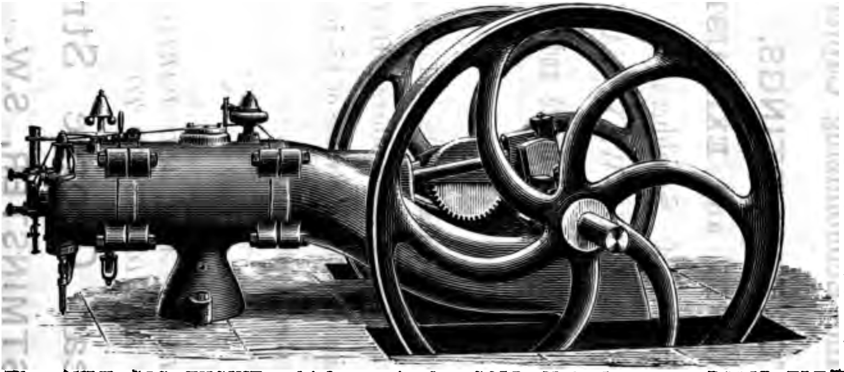
THE "OTTO" GAS ENGINE.

OVER 9000 ALREADY DELIVERED.



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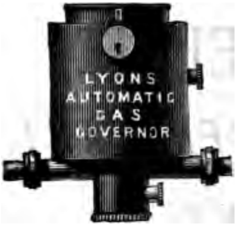

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AND

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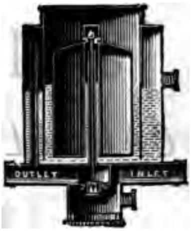

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Governors on this principle are constructed for Stations, Districts, or Consumers.

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To give the Maximum Amount of Gas, it will supply from a single light to the full number at an Unvarying Pressure. The result is

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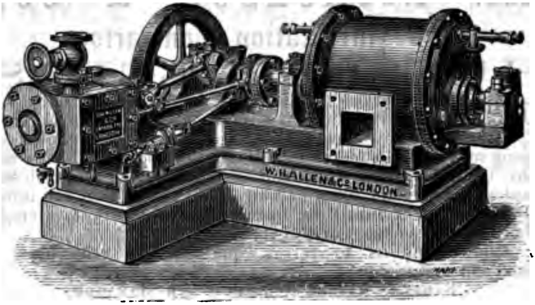
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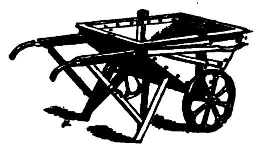

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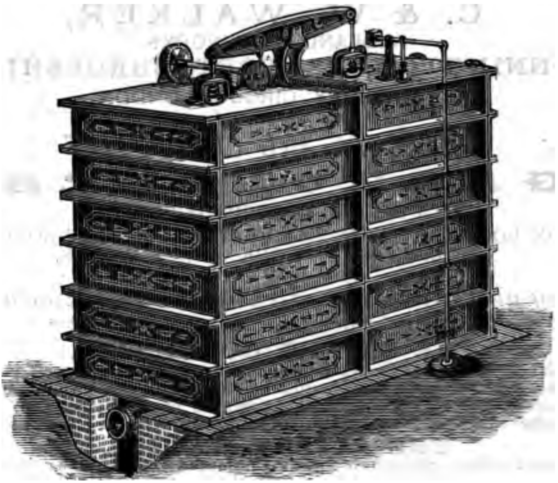

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